POMOLOGY-II
Practical Manual
for
CLASS-XII

CENTRAL BOARD OF SECONDARY EDUCATION, DELHI
Shiksha Kendra, 2 Community Centre, Preet Vihar, Delhi-110092
भारत का संविधान

उदेशिका
हम, भारत के लोग, भारत को एक सम्पूर्ण 'प्रभुत्व-संपन समाजवादी पंथिकरपेश्च लोकतंत्रात्मक गणराज्य बनाने के लिए, तथा उसके समस्त नागरिकों को:

सामाजिक, आर्थिक और राजनैतिक न्याय,
विचार, अभिव्यक्ति, विश्वास, धर्म

और उपासना की स्वतंत्रता,
प्रतिष्ठा और अवसर की समता

प्राप्त कराने के लिए
tथा उन सब में व्यक्ति की गरिमा

'और राष्ट्र की एकता और अखंडता
सुनिश्चित करने वाली बंधुता बढ़ाने के लिए

बुद्धिस्मकल्प होकर अपनी इस संविधान सभा में आज तारीख 26 नवम्बर, 1949 को एवं द्वारा इस संविधान को अंगीकृत,
अधिनियमित और आवश्यकित करते हैं।

1. संविधान (बयालीच्या संस्करण) अधिनियम, 1976 की धरा 2 द्वारा (3.1.1977) से "प्रभुत्व-संपन लोकतंत्रात्मक गणराज्य" के स्वातंत्र्य पर प्रतिष्ठापित।
2. संविधान (बयालीच्या संस्करण) अधिनियम, 1976 की धरा 2 द्वारा (3.1.1977) से "राष्ट्र की एकता" के स्वातंत्र्य पर प्रतिष्ठापित।

भाग 4 क
मूल कर्त्तव्य

51 का, मूल कर्त्तव्य – भारत के प्रत्येक नागरिक का यह कर्त्तव्य होगा कि वह –

(क) संविधान का पालन करे और उसके आदेशों, संस्थाओं, राष्ट्रीय और राष्ट्रों का आदर करे;
(ख) स्वतंत्रता के लिए हमारे साधारण आदेशों का प्रतिष्ठा करने वाले उच्च आदेशों का हद में संयुक्त रखे और उनका पालन करे;
(ग) भारत की प्रभुत्व, एकता और अखंडता की रक्षा करे और उसे अविचरण रखे;
(घ) देश की रक्षा करे और आज्ञानुसार जाने पर राष्ट्र की सेवा करे;
(ङ) भारत के सभी लोगों में समर्पण और समान भावुकता का पालन करने को जो धर्म, भाषा और प्रदेश या वर्ग पर आधारित सभी भेदभाव से परे हो, ऐसी धर्माओं का प्राप्ति करने जो सहित्यों के समान के विरुद्ध हैं;
(च) हमारी सामाजिक संस्कृति की गौरवशाली परंपरा का महत्त्व समझे और उसका परिशोषण करे;
(छ) प्राकृतिक पर्यावरण की जिसके अंतर्गत वन, झील, नदी, और वन जैसे हैं, रक्षा करे और उसका संरक्षण करने तथा प्राणीमात्र के प्रति दयाभाव रखे;
(ज) वैज्ञानिक दृष्टिकोण, मानववाद और ज्ञानजीन्तुता तथा सुधार का भावना का विकास करे;
(झ) सावधानिक संचरित को सुरक्षित रखे और हिंसा से दूर रहे;
(ञ) व्यवहारिक और सामूहिक गतिविधियों के सभी क्षेत्रों में उत्कृष्ट को और बढ़ाने का सतत प्रयास करे जिससे राष्ट्र निरंतर बढ़ते हुए प्रगति और उपलब्धि की नई उंचाईयों का बीड़ ले;
(ट) यदि माता-पिता या संरक्षक है, छह वर्ष से चौथे वर्ष तक की आदु वाले अपने, यथार्थता, बालक या प्रतिपालन के लिये शिक्षा के अवसर प्रदान करे।

1. संविधान (बयालीच्या संस्करण) अधिनियम, 2002 द्वारा प्रतिष्ठापित।
THE CONSTITUTION OF INDIA

PREAMBLE

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC and to secure to all its citizens:

JUSTICE, social, economic and political;

LIBERTY of thought, expression, belief, faith and worship;

EQUALITY of status and of opportunity; and to promote among them all

FRATERNITY assuring the dignity of the individual and the unity and integrity of the Nation;

IN OUR CONSTITUENT ASSEMBLY this twenty-sixth day of November, 1949, do HEREBY TO OURSELVES THIS CONSTITUTION.

1. Subs, by the Constitution (Forty-Second Amendment) Act. 1976, sec. 2, for "Sovereign Democratic Republic (w.e.f. 3.1.1977)
2. Subs, by the Constitution (Forty-Second Amendment) Act. 1976, sec. 2, for "unity of the Nation (w.e.f. 3.1.1977)

THE CONSTITUTION OF INDIA

Chapter IV A

Fundamental Duties

ARTICLE 51A

Fundamental Duties - It shall be the duty of every citizen of India-

(a) to abide by the Constitution and respect its ideals and institutions, the National Flag and the National Anthem;

(b) to cherish and follow the noble ideals which inspired our national struggle for freedom;

(c) to uphold and protect the sovereignty, unity and integrity of India;

(d) to defend the country and render national service when called upon to do so;

(e) To promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities; to renounce practices derogatory to the dignity of women;

(f) to value and preserve the rich heritage of our composite culture;

(g) to protect and improve the natural environment including forests, lakes, rivers, wild life and to have compassion for living creatures;

(h) to develop the scientific temper, humanism and the spirit of inquiry and reform;

(i) to safeguard public property and to abjure violence;

(j) to strive towards excellence in all spheres of individual and collective activity so that the nation constantly rises to higher levels of endeavour and achievement.
India is the 2nd largest producer of fruits in the world. However the productivity of majority of the fruit crops is lower than its potential. There are several reasons for the low productivity of which unawareness about technological advancement in fruit production is considered to be the major one.

Considering the importance of horticulture, CBSE has introduced Vocational Elective: Pomology –II for class XII students. For effective teaching and understanding of the course, a Practical Manual has also been prepared with the following objectives:

- To create awareness among the students about important cultural operations in fruit orchards for better management and realizing higher income from the orchards.

- To impart knowledge about high density orcharding, micro-irrigation system installation, pruning & training, fertilization, rejuvenation of old and declining orchards and management of diseases and insect pests.

- To train students for efficient management of fruit orchards and providing consultancy to other growers for higher production and productivity. This would also help rural youths towards employment and agri-business management.

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I am optimistic that after doing practical, and visiting orchards units, & laboratories etc, students will be benefited. They can also think of joining these sectors in their future life and can develop themselves as successful entrepreneur in such areas. It is hoped that this Practical Manual will be an asset for the students at entry level.

Vineet Joshi, IAS
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<th>Page No.</th>
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</thead>
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<td>2.</td>
<td>Identification of fruit trees and varieties</td>
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<td>Studying fruit setting and fruit dropping in important fruit crops</td>
<td>10</td>
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</tr>
<tr>
<td>24.</td>
<td>Rejuvenation of old and senile fruit orchards</td>
<td>100</td>
</tr>
</tbody>
</table>
Exercise
Visit to high density orchards of fruit crops.

Objectives

- To know about high density orcharding in fruit crops.
- To learn about establishment of high density orchards.

Delivery schedule: 01 period

Student expectations/learning objectives:

- To know about high density orcharding in fruit crops.
- To know about advantages and limitations of high density orcharding in fruit crops.

Handouts/material/equipment's & tools required: Practical note book, pen, and pencil to note down the important points on establishment of high density orchards in fruit crops.

Pre-learning required: Pre-requisite knowledge about planting systems of fruit trees, and different fruit crops grown in the locality.

Introduction

High Density Planting (HDP) is a very intensive form of fruit production which has high relevance to the food and nutritional security of our ever increasing population. HDP system is normally understood as a system in which a higher number of plants are accommodated within a unit area in comparison to the conventional planting density. Hence, interest in HDP in fruit crops has increased considerably among fruit growers. Many fruit trees are now grafted on to size controlling clonal rootstocks and planted at much higher densities.

The high density planting has certain definite advantages as well as limitations compared to the conventional low density planting. It is worth mentioning here that under high density planting system the yield per plant in low as compared to low density planting. However, the total yield per unit area of land is several times more than low density planting as number of plants is more in HDP.

Advantages

- High density planting facilitates better utilization of incident solar radiation and increase in bearing surface per unit land area.
- High density orchards have better amenability to modern input saving horticultural techniques such as drip irrigation, mechanical harvest etc.
• The use of dwarf trees and checking of excessive vegetative growth gives higher productivity and harvest index as well as early economic returns.

• High density planting system is more amenable to horticultural operations such as pruning, plant protection measures and harvesting, which reduces the labour cost involved.

Limitations

• High density planting needs higher establishment cost.

• Need more professional and scientific approach for management compared to the conventional planting at wider spacing.

• Crowding and intermingling of branches may occur in coming years which can result in poor performance of trees.

Key aspects of high density planting

• Use of dwarfing rootstock and scion cultivars

• Use of clonal rootstock

• Pruning of plants

• Use of growth retardants

• Training system

• Light interception

• Planting density

• Row orientation and rectangularity

• Canopy management

Steps involved in establishment of high density orchards

Example: Mango

• Germinate mango stones in situ at the planting distance of 2.5 x 2.5 meters.

• Graft rootstock seedlings in situ with Amrapali scion.

• Apply 10 kg of Farm Yard manure (FYM) and 0.5 kg fertilizer mixture (ammonium sulphate, single super phosphate and sulphate of potash in 1:3:1 ratio) in first year.
• Increase doses of FYM by 10 kg each year up to seven years age of the tree and that of fertilizer mixture to 1.0 kg during second and third year, to 1.5 kg during fourth and fifth year and to 2.0 kg later on.

• Apply full quantity of FYM during October, whereas, fertilizer mixture in single dose in July up to three years and subsequently in two split doses (first after harvest and the second in September).

• Irrigate trees at fortnightly interval during summer and at monthly interval in winter during non-fruiting stage. Irrigate bearing trees at fortnightly interval from marble stage of fruit to fruit maturity.

• It was observed that after 11 years of planting yield of orchard drastically reduced due to overlapping canopy of adjoining trees. Therefore, exercise judicious pruning to manage the canopy and to remove intermingling branches which allows proper sun light penetration and results in better yield and quality.

For teachers…
• Arrange visit of fruit orchards and explain differences between low density and high density planting systems.
• Ask students to practice in situ planting of seedlings and grafting scion variety on seedlings.
• Demonstrate layout procedure for high density planting in fruits.
Planting distance and total number of trees

The knowledge of traditionally recommended planting densities in fruit crops is a must. For example most of the mango varieties are recommended to be planted at a distance of 10 m (row to row) x 10 m (plant to plant) under square system of planting and a total of 100 plants can be accommodated in a hectare area. In comparison to traditionally recommended planting distance, dwarf varieties of mango like 'Amrapali' is recommended to be planted at a distance of 2.5 m (between rows) and 2.5 m (between plants). In this condition, total 1,600 plants can be accommodated in one hectare area following triangular system of planting.

Calculation of number of trees: Students can know the total number of plants accommodated in one hectare area by following formula.

One hectare = 10,000 m²
Total number of plants / hectare = 10,000 / {row to row distance (R) x plants to plantdistance(P)}

Example 1

<table>
<thead>
<tr>
<th>Plant to Plant (m)</th>
<th>Row to Row (m)</th>
<th>10,000 / (R X P)</th>
<th>Total No. of Plants/hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2</td>
<td>= 10,000 / 4</td>
<td>2,500</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>= 10,000 / 9</td>
<td>1,111</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>= 10,000 / 16</td>
<td>625</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>= 10,000 / 25</td>
<td>400</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>= 10,000 / 36</td>
<td>278</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>= 10,000 / 49</td>
<td>204</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>= 10,000 / 64</td>
<td>156</td>
</tr>
<tr>
<td>9</td>
<td>9</td>
<td>= 10,000 / 81</td>
<td>123</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>= 10,000 / 100</td>
<td>100</td>
</tr>
</tbody>
</table>

By observing the above table it is clear that with the decrease in planting distance the number of plants which can be accommodated in a hectare is increasing. Students can calculate number of plants for any specified area of land if they know the planting distance.

Students Activities

1. Calculate the number of plants for one hectare land with given planting distances in the following exercise table 1.

2. Visit fruit orchards in your locality and observe planting system and distance between rows and plants.

Exercise table 1.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Row to Raw Distance (m)</th>
<th>Row to Raw Distance (m)</th>
<th>Calculation as per Formula</th>
<th>Total number of plants / hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mango</td>
<td>3.0</td>
<td>2.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guavava</td>
<td>1.0</td>
<td>2.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Papaya | 1.25 | 1.25 |  
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pineapple</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>Banana</td>
<td>2.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>

**Study Material**


Exercise
Identification of fruit trees and varieties.

Objectives

- To know about important fruit trees and their varieties in the locality.

Delivery schedule: 01 period

Student expectations/learning objectives

- Identification of important fruit trees in the locality.
- To know about varieties of important fruit trees.

Handouts/material/equipment's & tools required: Practical note book, pen, and pencil to note down the important points in the identification of important fruit trees and varieties.

Pre-learning required: Pre-requisite knowledge of different types of fruit trees, and their varieties.

Introduction

India is endowed with varying climatic conditions and different fruit trees are grown in different localities on the basis of their climatic requirements. The fruit trees are classified into different categories like temperate, sub-tropical and tropical fruit trees. Temperate fruit trees are exacting in their climatic requirement. They can tolerate both diurnal and seasonal wide fluctuations of temperature. They are grown only in place where winter is distinctly cold. These fruit trees require an exposure of specific chilling requirement for certain period without which they do not flower. These fruit plants are generally deciduous and can stand frost like, apple, pear, peach, almond, walnut, apricot, plum, strawberry etc.

Tropical fruit trees are generally evergreen and are extremely sensitive to cold. They require a moist warm climate but are capable of withstanding dry weather in some cases. Example of tropical fruit crops are banana, coconut, papaya, sapota, mango, pineapple etc. Similarly, sub-tropical fruit trees are grown under a climate which is in between temperate and tropical. They may be either deciduous or evergreen and are usually able to withstand low temperature but not the frost like loquat, litchi, pomegranate, citrus fruits etc. In addition, some of the plants are hardy and can thrive well under extreme dry conditions like lasoda, khirni, bael, ber, datepalm etc. It is important to mention here that some of the temperate fruit crops or their varieties can also be grown in sub tropical conditions like, low chill peaches, apples and plums. Similarly, majority of tropical fruit crops like papaya, mango, banana etc. can also be grown in subtropical regions provided problem of frost is

For teachers…

- Explain to students the differences between temperate, subtropical and tropical fruits.
- Practically, show different fruit trees and their fruits.
- Practically show the varietal differences in fruit shape, size, colour etc.
not there in the locality. It is very important that students should have knowledge about the fruit trees which are common in their locality. Not only the type of fruit tree but knowledge about variety(ies) of important fruit trees is equally important. A list of commonly grown fruit trees and varieties under different climatic conditions are given in table 1 and 2.

Table 1. Fruit trees under different climatic conditions

<table>
<thead>
<tr>
<th>Temperate region</th>
<th>Sub-tropical region</th>
<th>Tropical region</th>
<th>Arid region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>Mandarin</td>
<td>Banana</td>
<td>Bael</td>
</tr>
<tr>
<td>Apricot</td>
<td>Mosambi</td>
<td>Coconut</td>
<td>Khirni</td>
</tr>
<tr>
<td>Walnut</td>
<td>Mango</td>
<td>Papaya</td>
<td>Phalsa</td>
</tr>
<tr>
<td>Blue berry</td>
<td>Lemon</td>
<td>Mangosteen</td>
<td>Lasora</td>
</tr>
<tr>
<td>Cherry</td>
<td>Grape</td>
<td>Guava</td>
<td>Wood apple</td>
</tr>
<tr>
<td>Crane berry</td>
<td>Aonla</td>
<td>Date palm</td>
<td>Pilu</td>
</tr>
<tr>
<td>Grape</td>
<td>Guava</td>
<td>Sapota</td>
<td>Bread fruit</td>
</tr>
<tr>
<td>Pecan Nut</td>
<td>Pineapple</td>
<td>Mango</td>
<td>Karanada</td>
</tr>
<tr>
<td>Peach</td>
<td>Pomegranate</td>
<td>Cashew nut</td>
<td>Ker</td>
</tr>
<tr>
<td>Pear</td>
<td>Litchi</td>
<td>Custard apple</td>
<td>Ber</td>
</tr>
<tr>
<td>Plum</td>
<td>Loquat</td>
<td>Tamarind</td>
<td>Phalsa</td>
</tr>
</tbody>
</table>

Table 2. Common fruit trees and their varieties

<table>
<thead>
<tr>
<th>Almond</th>
<th>California Paper Shell, Drake, Non Pariel, Prabhat, Waris, Shalimar, Makdooom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aonla</td>
<td>Banarasi, Hathi jhool, Chakaiya, Kanchan, Krishna, Laxmi-52, Balwant</td>
</tr>
<tr>
<td>Apple</td>
<td>Red Delicious, Golden Delicious, Ambri, McIntosh, Early Shanbury, Royal Delicious, Fuzi, Royal Gala, Red Spur, Granny Smith, Jonathan, Pink Lady</td>
</tr>
<tr>
<td>Banna</td>
<td>Dwarf Cavendish, Gros Michel, Poovan, Monthan, Nendran, Harichal, Robusta, Basrai Dwarf</td>
</tr>
<tr>
<td>Ber</td>
<td>Gola, Banarsi Karaka, Umran Seb, Ponda, Sannaur</td>
</tr>
<tr>
<td>Coconut</td>
<td>West Coast Tall, Chaowght Green Dwarf, Malayan Dwarf Yellow, Dwarf Green, Dwarf Orange, Kera Ganga, Kera Sankara, Chandra Laksha</td>
</tr>
<tr>
<td>Custard Apple</td>
<td>Arka Sahan, Balanagar Local, Mammoth</td>
</tr>
<tr>
<td>Date palm</td>
<td>Zahidi, Hilawy, Khadrawy, Medjool, Sharman, Deglet Noor</td>
</tr>
<tr>
<td>Grape</td>
<td>Thompson Seedless, Perlette, Bangalore Blue, Anab-e-Shahi, Pusa Urvashi,</td>
</tr>
<tr>
<td>Guava</td>
<td>Pusa Navrang, Bhokri, Delight, Kismish Charni, Beauty Seedless</td>
</tr>
<tr>
<td></td>
<td>Allahabad Safeda, Lucknow-49, Lalit, Allahabad Surkha, Habsi, Behat Coconut,</td>
</tr>
<tr>
<td></td>
<td>Apple Colour, Seedless</td>
</tr>
<tr>
<td>Kiwifruit</td>
<td>Allison, Hayward, Abbott, Bruno, Monty</td>
</tr>
<tr>
<td>Lemon</td>
<td>Lisbon, Pant Lemon, Kagzi Kalan, Nepali lemon, Eureka, Baramasi, Italian</td>
</tr>
<tr>
<td>Lime</td>
<td>Kagzi lime, Vikram, Pramalini, Sai Sarbati, Tahiti lime, Seedless lime</td>
</tr>
<tr>
<td>Litchi</td>
<td>Dehradun, Calcuttia, Purabi, Muzzafarpur, Shahi, Rose Scented, Swarn Roopa</td>
</tr>
<tr>
<td><strong>Apple varieties</strong></td>
<td>California Advance, Improved Pale Yellow, Large Agra, Fire Ball, Thames Pride, Tanaka</td>
</tr>
<tr>
<td>---------------------</td>
<td>-------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Granny Smith</td>
<td>Fuzi</td>
</tr>
<tr>
<td>Jonathan</td>
<td>Royal Gala</td>
</tr>
<tr>
<td>Golden Delicious</td>
<td>Red Delicious</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Apple varieties</strong></th>
<th>Nagpur, Coorg, Khasi Mandarin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandarin</td>
<td></td>
</tr>
<tr>
<td>Mango</td>
<td>Dushehari, Langra, Chausa, Alphanso, Kesar, Totapuri, Safeda, Amrapali</td>
</tr>
<tr>
<td></td>
<td>Mallika, Pusa Arunima, Pusa Pratibha, Himsagar, Zardalu, Neelum, Tommy Atkins, Sensation, Carabao, Fazli, Haden</td>
</tr>
<tr>
<td>Papaya</td>
<td>Pusa Dwarf, Pusa Majesty, Pusa Delicious, Pusa Nanha, Ranchi, Coorg Honey Dew, Solo</td>
</tr>
<tr>
<td>Peach</td>
<td>Sharbati, Shahampur Prabhat, Fordasun, J H Hale, Shan-e-Punjab, Earligrande, Red bartlett</td>
</tr>
<tr>
<td>Pear</td>
<td>Le Conte, Patharnakh, Gola, Smith, Baghugosha, Bartlett, Conference</td>
</tr>
<tr>
<td>Pineapple</td>
<td>Kew, Queen, Smooth Cayenne, Red Spanish, Singapore, Sugar Loaf, Abacaxi</td>
</tr>
<tr>
<td>Plum</td>
<td>Satulej Purple, Santa Rosa, Stanley, Kala Amritsari, Titron, New Castle, Kelsey</td>
</tr>
<tr>
<td>Pomegranate</td>
<td>Alandi, Ganesh, Muskat, Basin Seedless, Khandari, Dholka, Jyothi, Mridula, Rubi</td>
</tr>
<tr>
<td>Sapota</td>
<td>Cricket Ball, Kallipatti, Bhuripatti, Guthi, Oval</td>
</tr>
<tr>
<td>Strawberry</td>
<td>Chandler, Tioga, Torrey, Sweet Charlie, Camarosa, Fern, Etna</td>
</tr>
<tr>
<td>Sweet Orange</td>
<td>Mosambi, Malta, Valencia, Blood Red, Jaffa, Hamlin, Washington</td>
</tr>
</tbody>
</table>

| **Walnut**          | Karan, Bulbul, Gobind, Wilson, Wonder Prolific, Hartley, Franquette                 |
**Students Activities**

1. Visit fruit orchards in your locality and try to identify the fruit trees and their varieties.
2. Write down the morphological differences of varieties of important fruit crops of your locality.

**Study Material**

Exercise

Studying fruit setting and fruit dropping in important fruit crops.

Objectives

- To know about fruit setting and fruit drop in important fruit crops in the locality.
- To know about causes of fruit drops fruit crops in the locality.
- To know about the pattern of fruit drop fruit crops in the locality.

Delivery schedule: 02 periods

Student expectations/learning objectives

- To know about factors responsible for fruit set.
- To know the causes of fruit drop in important fruit crops.

Handouts/material/equipment's & tools required: Practical note book, pen and pencil, to note down the important points on fruit set and drop in fruit crops. Aluminum/paper tags and Vernier Caliper, magnifying lens, small portable balance to measure size and weight of dropped fruits.

Pre-learning required: Pre-requisite knowledge about pollination, fertilization fruit growth and development processes in important fruit crops.

Introduction

There may be plenty of flowers on your plants, but you're not getting any fruit. What's going on? The flowers have not been pollinated properly. They have either not been pollinated at all, have been pollinated under the wrong conditions, or pollination has been insufficient. Fruit set may be explained as the initiation of process of formation of fruit from the flower tissues after successful pollination and fertilization. However, in certain cases fertilization is not necessary due to parthenocarpic fruits are formed. In general, it is observed that fruit trees flowers profusely and set fruits, but the ultimate retention of mature fruits is very low. This primarily happens due to drop of flowers and fruits at different developmental stages. Fruit drop is a common problem of majority of fruit species, but it is very high in fruit crops like mango, citrus, apple, pear, sapota, coconut and stone fruits. For example, there are 1000 to 6000 flowers per panicle in mango, but less than 0.1 per cent reaches maturity. Scientists are of opinion that 0.1 per cent fruit set in mango, 4-5 per cent in citrus and 3-4 per cent in temperate fruits is sufficient to bear a normal crop. It means about 95-99 per cent flowers either do not set fruits, and if they set, the fruit drop off in subsequent stages of their development. Fruit drop at initial stage of development is considered as a necessary evil because it saves the tree from exhaustion. Whereas, fruit drop in later part of fruit development has negative effect on fruit yield from the tree. It is therefore necessary for the students to know
about fruit set and fruit drop in the trees available in their locality. Furthermore, the knowledge about waves of fruit drop and causes of fruit drop is equally important.

**Waves of fruit drop**

Fruit drop occurs at different stage of fruit development and in series of waves. The number of waves varies with the fruit species and climatic conditions prevailing in the locality. There are certain disagreements among pomologists about waves of fruit drop in different fruit crops. However, based on fruit size, intensity and economic loss the fruit drop has been categorised in three waves.

1. **Pin-head drop:** This wave mainly consists of drop of abnormal, shrivelled floral organ and unpollinated flowers. This drop also includes small pin-head like fruits. It occurs shortly after fruit set and usually lasts for a month following full bloom. This fruit drop is sometimes considered desirable if the initial fruit set is excessive.

2. **Post-set drop:** In this phase, the fruit drop off after they have set. It consist of drop of the fruits having diameter between 4 mm to 16 mm. The drop of fruits is variable in different cultivars, but differences are small. Post-set drop is considered as major drop in mango and many other fruits. The drop becomes prominent in mid-April in mango.

3. **May drop:** From economic point of view, may drop is most important because it consist of drop of fully mature fruits just before harvesting. It continues upto May and sometimes in June also in mango. It is also called as pre-harvest drop in many fruit trees.

**Causes of fruit drop**

---

**For teachers…**

- Explain to students the pollination and fertilization processes in fruit crops.
- Make students to understand parthenocarpic fruit development.
- Practically show tagging and thinning of flowers for observing fruit set or drop.
• Genetic factors

• Climatic factors
  * Extremes of temperature
  * Low humidity
  * High wind velocity
  * Storm, hail etc.

• Pathological factors
  * Fungal diseases
  * Bacterial diseases
  * Viral diseases
  * Nematodes

• Entomological factors
  * Infestation of insects and pests

• Physiological factors
  * Defective flower
  * Embryo abortion
  * Disturbed water relations
  * Malnutrition
  * Lack of pollinizer and pollinators
  * Poor pollen transfer
  * Hormone imbalance

**Procedure to observe fruit set and drop in fruit trees (example-mango)**

**Steps**
1. Tag ten panicles in different directions north, south, east and west of mango tree.
2. Thin flowers and retain definite number of hermaphrodite (bisexual) flowers per panicle.
3. Count number of flowers sowing sign of fruit set (Initial fruit set).
4. Count number of fruits retained at weekly interval.
How to calculate fruit set and drop in fruit trees

a. Fruit set (%) = \( \frac{\text{Final Fruit Number}}{\text{Initial Fruit Number}} \times 100 \)

b. Fruit drop (%) = \( \frac{100 - \text{Final Fruit Number}}{\text{Initial Fruit Number}} \times 100 \)

c. Rate of fruit drop (Q) = \( \frac{\log X_1 - \log X_2}{t_1 - t_2} \)

Where,

- \( X_1 \) = number of fruits at time \( t_1 \)
- \( X_2 \) = number of fruits at time \( t_2 \)

Students Activities

1. Visit some fruit orchards in your locality during flowering and fruiting seasons and observe fruit set and retention at an interval.

2. Calculate fruit set percentage, fruit drop percentage and rate of fruit drop from the following table using above formula.

<table>
<thead>
<tr>
<th>Fruit</th>
<th>Number of fruits (Initial fruit set)</th>
<th>Number of fruits at intervals (week)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Mango</td>
<td>100</td>
<td>75</td>
</tr>
<tr>
<td>Citrus</td>
<td>100</td>
<td>85</td>
</tr>
<tr>
<td>Guava</td>
<td>100</td>
<td>77</td>
</tr>
<tr>
<td>Sapota</td>
<td>100</td>
<td>62</td>
</tr>
<tr>
<td>Coconut</td>
<td>100</td>
<td>44</td>
</tr>
</tbody>
</table>

Results

a. Fruit set (%)

<table>
<thead>
<tr>
<th>Fruit</th>
<th>Fruit set (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Mango</td>
<td></td>
</tr>
<tr>
<td>Citrus</td>
<td></td>
</tr>
<tr>
<td>Guava</td>
<td></td>
</tr>
<tr>
<td>Sapota</td>
<td></td>
</tr>
<tr>
<td>Coconut</td>
<td></td>
</tr>
</tbody>
</table>
b. **Fruit drop (%)**

<table>
<thead>
<tr>
<th>Fruit</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mango</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Citrus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guava</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sapota</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coconut</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Study Material**

Exercise
Laying out of different systems of irrigation for young and adult fruit trees.

Objectives

- To know about irrigation systems in fruit trees.
- To know about use of micro-irrigation systems in fruit trees.

Delivery schedule: 02 periods

Student expectations/learning objectives

- To learn about laying out of irrigation systems in fruit trees.
- To learn about advantages and disadvantages of irrigation systems in fruit trees.

Handouts/material/equipment's & tools required: Practical note book, pen and pencil to note down the important points on laying out irrigation systems.

Pre-learning required: Pre-requisite knowledge about planting systems of fruit trees and irrigation requirement of young and adult fruit trees.

Introduction

Success in fruit culture largely depends upon availability of supplemental irrigation, particularly during critical period of tree growth and development. Irrigation is done to supplement the deficit in soil water. While doing so, the major aspects to be considered relate to the time, quantum and methods of irrigation. The installation of irrigation system is a pre-requisite to plantation of fruit trees. The main source of irrigation should be either dug-well or deep tube well and those should be installed at the highest elevation. Different methods of irrigation have been used in fruit orchards depending on water availability, topography, fruit species, age of tree, intercrops etc. On sloppy lands and in the hills, contour basin, furrows, sprinkler and drip irrigation methods are suitable whereas in the plains, rectangular or square check basins, circular basins (rings), furrows, sprinkler and drip irrigation systems can be used. Selection of irrigation system is mainly dependent on availability of water in the locality. In the areas where water is scare, sprinkler or drip irrigation is better for fruit crops. All these systems of irrigation have their merits and demerits.

Irrigation in young fruit trees

The purpose of irrigation of young fruit trees in the orchards is to boost fast and vigorous growth of the tree. In initial stage the root spread of the tree is limited. Light irrigation at frequent intervals is required to wet the soil. The non-bearing trees 4-5 years of age are irrigated at weekly interval. The interval of irrigation depends upon tree age, soil and climate. For the first six months after planting, interval should be 2 to 6 days, for 6 to 12
months old plant at weekly interval and 7 to 20 days till the plants attain bearing age. In light soil, irrigation frequency is more than in heavy soils. During winter, the irrigation is specially required for protection against frost. In heavy soils, frequent irrigation causes damage to root system and stem so it should be avoided. But the interval should not be too long so that plant faces moisture stress and the growth and spread is checked.

**Irrigation in adult fruit trees**

The irrigation of orchards having adult trees should be done at regular intervals (10 to 15 days). Sufficient moisture in the soil is of prime necessity during fruit set and for full fruit development. It is helpful in attaining full fruit size and reducing fruit drop. But to obtain good flowering, the irrigation during flower bud differentiation should be stopped. Irrigation during this period promotes vegetative growth, which will be detrimental to flowering. In light soils, the interval of irrigation would be high during hot, dry and windy weather than in cold and calm atmosphere.

**Important points in selection of irrigation system**

- Source of water supply
- Availability of water
- Quality of irrigation water
- Topography of land to be irrigated
- Soil type
- Climate of the area
- Fruit species grown
- Age of the fruit trees
- Critical period of plant growth
- Cultural practices in the orchard
- Economics

**Systems of irrigation**

In fruit orchards mainly following systems of irrigation is practiced in India.
1. **Surface irrigation:** In surface irrigation systems water is moving over the land by simple gravity flow in order to wet it and to infiltrate into the soil. They can be subdivided into furrow, border strip or basin irrigation.

2. **Localized irrigation:** Localized irrigation is a system where water is distributed under low pressure through a piped network, in a pre-determined pattern, and applied as a small discharge to each plant or adjacent to it. Drip irrigation, spray or micro-sprinkler irrigation and bubbler irrigation belong to this category of irrigation methods.

3. **Sprinkler irrigation:** In sprinkler or overhead irrigation, water is piped to one or more central locations within the field and distributed by overhead high-pressure sprinklers or guns. A system utilizing sprinklers, sprays, or guns mounted overhead on permanently installed risers is often referred to as a solid-set irrigation system. Higher pressure sprinklers that rotate are called rotors and are driven by a ball drive, gear drive, or impact mechanism.

4. **Manual irrigation by buckets or watering canes:** This system is not suitable for adult trees as their water requirement is very high. Manual irrigation is generally practiced for newly planted fruit trees in the backyard.

**Common irrigation methods in fruit orchards**

A number of irrigation methods like basin, ring, furrow, flood, sprinkler and drip are employed. Each method has advantages and disadvantages as one method may be suitable for one set of conditions but unsuitable for another. Therefore, proper selection of the irrigation method is important for better orchard management practices.

**Flood irrigation:** This system is adopted in such orchards where sufficient water is available. Here entire area of orchard is wetted and meets the water requirement of tree and suited best to the extensive root system of fruit tree. It is not a desirable method of irrigation as water loss is very high, introduction of weeds and diseases is possible and health of plant is adversely affected in the event of stagnation of water for some period.

**Furrow method of irrigation:** In this method 2-3 furrows are made along the row on both sides. This system is suitable for the places where the flow of water is so regulated that it moves with slow speed. Here the plants are irrigated through lateral movement of water. Although this system is good but not adopted at large scale.

**Strip irrigation:** In this method of irrigation, entire orchard is divided in small and manageable strips having one or two fruit tree rows. These strips are attached to the main water channel and water movement is free along the slope in the strip. The slope should be minimum which helps in slow movement of water and allows every part of the strip to be wetted equally by irrigation water.

**Basin system:** In this system of irrigation, small circular basins are made around the tree trunks. These
basins are connected with each other through a straight channel. The water passing through these channels touch the tree trunk directly. Such type of flow from plant to plant may cause damage and manures and fertilizers may be washed away with water and deposited at the end of the channel. The disease present in one plant may spread to other plants. The effective root zone is not properly irrigated.

Ring system: This system is an improvement over previous systems. The irrigation channel is made between two rows of trees. Here the basins are kept small having circular shape. The individual basin is connected by sub-channel to the channel formed between two rows. Due to small size of basin, adequate amount of water is not accommodated which is sufficient for plant.

Sprinkler system: The sprinkler system is ideal in areas where water is scarce. A Sprinkler system conveys water through pipes and applies it with a minimum amount of losses. Water is applied in form of sprays sometimes simulating natural rainfall. The difference is that this rainfall can be controlled in duration and intensity. If well planned, designed and operated, it can be used in sloping land to reduce erosion where other systems are not possible. Sprinkler irrigation system consists of “head” and a distribution network. A pump, filter, flow meter (optional), pressure gauge, fertilizer injector (optional), pressure regulator, and controller (optional for manual systems) generally make up a system head.

Drip irrigation: In this system water is directly applied to the root zone. Drip irrigation system delivers water to the crop using a network of mainlines, sub–mains and lateral lines with emission points spaced along their lengths. Each dripper/emitter, orifice supplies a measured, precisely controlled uniform application of water and nutrients, directly into the root zone of the plant. Water and nutrients enter the soil from the emitters, moving into the root zone of the plants through the combined forces of gravity and capillary. In this way, the plant's withdrawal of moisture and nutrients are replenished almost immediately, ensuring that the plant never suffers from water stress, thus quality, growth and yield is improved.

Students Activities
1. Visit fruit orchards in your locality and note down the irrigation systems adopted in fruit orchards.
2. Visit fruit orchard having drip irrigation system.
3. Practically see different parts of drip irrigation system and enquire about role of different parts in regulating irrigation.

Study Material


Exercise
Planting of fruit crops.

Objectives

- To learn about planting of fruit crops.
- To know planting distance and operation during planting of fruit crops.
- To know about important steps in planting of fruit crops.

Delivery schedule: 02 periods

Student expectations/learning objectives

- To know about planting procedures of fruit crops.
- To know about planting distance and time of planting in fruit crops.

Handouts/material/equipment’s & tools required: Practical note book, pen, and pencil to note down the important points on planting procedures, secateurs, gloves, spade etc.

Pre-learning required: Pre-requisite knowledge about cultivation of fruit crops.

Introduction

Orchard establishment is a long term investment and mistakes committed at initial stage of establishment have long effect on the productivity of the orchard and income from the orchard. Therefore, utmost care should be taken to select type of fruit crops, varieties suitable for the locality and planting of fruit trees. There are other operations before actual planting of fruit trees is started, which are no less important for survivability of the individual sapling as well as the whole orchard like, methods of digging the planting pits, season and direction of planting. It is important for the students to have knowledge about planting procedures of fruit trees like papaya, citrus and mango.

Principle

Soil preparation: The soil of the area destined for growing fruit trees needs thorough preparation. If the selected land is under regular cultivation, it is logical that less effort is required to prepare the soil. A virgin soil requires a deep ploughing and harrowing. Ploughing the land repeatedly with mould board plough followed by crosswise harrowing will bring the soil to a fine tilth and pulverize the weeds or other undesirable herbs under the soil. However, the deep subsoil having less fertility should not be disturbed or brought on the surface unnecessarily. The land if undulated should be leveled with an appreciable gradient for drainage of surplus water. In hilly areas, the leveling is done along the contour in various terraces.
**Layout:** The layout of the orchard is one of the important operations prior to establishment of the same. The layout is broadly aimed at i) to provide adequate space to the plants for proper growth and production without any crowdedness in future, ii) to avoid misuse of land space and to accommodate more number of plants per unit area for economic viability, iii) to help proper utilization of natural resources and inputs respectively by the plants and iv) to allow free movement of machinery for easy intercultural operations. There should be provision of paths, farmstead building, irrigation channels, fencing, wind breaks in fruit orchards. Some popular systems of planting in vogue are square, rectangular, triangular, diagonal, contour and hedgerow systems.

**Time of planting:** Season of planting of fruit trees is different. The deciduous fruit trees such as apple, pear, peach, apricot, plum etc. should be planted during their dormancy. It would be wise if, if the operation could be done well before the dormancy is over and the plant start growth afresh during the subsequent period. Most of the deciduous fruit trees go under dormancy during winter. In that case, the time of planting season should be adjusted accordingly, so that minimum shock is experienced by the seedling. In contrast, most of the tropical and sub-tropical evergreen fruit trees are suitably transplanted in the rainy season when the atmospheric humidity is high and ample supply of soil moisture is obtained. The plants, during this period of their active growth, easily penetrate their roots in soil and get established. In case of easy availability of appreciable quality of irrigation water, then sapling of fruit trees may also be planted during the onset of spring.

**Plant spacing:** Proper spacing regulates the proper utilization of solar energy, avoid competition for uptake of nutrients caused by the collision of root system, facilitates irrigation, perfectly accommodates the leaf canopy of the individual tree and on the whole adds to the decency of the plantation area. Recommended tree spacing for some important fruit trees are mentioned in Table 1.

### Table 1. Recommended spacing for important fruit trees.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Fruit crop</th>
<th>Spacing (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Apple on M9 rootstock</td>
<td>3 X 2</td>
</tr>
<tr>
<td>2</td>
<td>Apple on M26 rootstock</td>
<td>3 X 3</td>
</tr>
<tr>
<td>3</td>
<td>Apple on MM106 rootstock</td>
<td>5 X 5</td>
</tr>
<tr>
<td>4</td>
<td>Mango</td>
<td>10 X 10</td>
</tr>
<tr>
<td>5</td>
<td>Amrapali mango under high density</td>
<td>2.5 X 2.5</td>
</tr>
<tr>
<td>6</td>
<td>Banana</td>
<td>2.3-3.0 X 2.3-3.0</td>
</tr>
<tr>
<td>7</td>
<td>Pineapple</td>
<td>0.45-0.60 X 0.30-0.45</td>
</tr>
<tr>
<td>8</td>
<td>Jack fruit</td>
<td>12 X 12</td>
</tr>
<tr>
<td>9</td>
<td>Guava, cashewnut, mulberry</td>
<td>6.8 X 6.8</td>
</tr>
<tr>
<td>10</td>
<td>Sapota, loquat, avocado</td>
<td>8.0 X 8.0</td>
</tr>
<tr>
<td>11</td>
<td>Mandarin, mosambi, lemon</td>
<td>7.0 X 7.0</td>
</tr>
<tr>
<td>12</td>
<td>Papaya</td>
<td>2.0 X 2.0</td>
</tr>
</tbody>
</table>

*For teachers…*

- Practically, show the students, how to layout a fruit orchard?
- Ask the students to note down the steps in planting of fruit trees.
Important steps in planting of mango

Field Preparation And Layout

- Selected fields should be deeply ploughed followed by harrowing.
- Proper levelling of land and a gentle slope is provided in one direction.
- The soils which have drainage problems, should be provided with adequate trenching.
- After field preparation one should go for layout. The main systems of layout are (i) Square, (ii) Rectangular, (iii) Quincunx, (iv) Hexagonal and (v) Contour.

Digging and filling of pits

- Before digging the pits, two outer pegs are fixed with the help of planting board.
- Already fixed peg is kept in the central notch to mark the right point to plant each tree.
- During digging of actual pit, the central peg is removed and two outer pegs remain undisturbed. These outer pegs help in locating the point where the plant is to be put in.
- The pit dimension size would be 1m x 1m x 1m dimension.
- The soil from upper half is kept on one side and from lower half on other side.
- This soil is allowed to weather for 2-4 weeks during summer months so that any type of infection in soil may be destroyed by sunlight.
- Before filling the pit, a mixture of well-decomposed FYM (40-50 kg), superphosphate (100 g), murate of potash (100 g) and fipronil dust (50 g) is prepared and mixed with upper as well as lower soil of the pit.
- The mixture of upper soil is filled first followed by lower soil mixture.
- During filling of pits soil is pressed well so that there is no air pocket inside the pit. The upper level of pit is kept 15 cm above from the field level.
- After filling, the pits are irrigated to settle down the soil of the pit.
- The purpose of digging and filling the pit is to provide congenial conditions for plant growth and development, specially to young plants.
Time of planting

- Mango planting is done during rainy season (July to August) and spring season (February to March) in North India.
- The planting is done in evening when the high humidity prevails in the atmosphere, while planting, one should be careful that the earth ball does not break during pressing the soil and the graft union remains well above the ground level. The plants should be irrigated just after planting. During first week of planting one should rectify the defects like sinking of soil and leveling of plants etc.

Selection of grafts for planting

- Mango grafts of desired cultivar should be procured from genuine sources. Normally, healthy grafts with smooth union give good performance in the field. Six-month to one year old grafts having upright scion growth with 3-4 scion branches are desirable for planting. Only those grafts should be procured which have been already shifted in the nursery bed to avoid the mortality in the field.

Planting of grafts

- At the time of planting, a slightly bigger hole than the size of earth ball is dug at the marked point. The wrapping material is removed from the ball and unrapped earth ball is put in the hole in such a manner that the plant remains straight and collar portion of plant is kept in the level or slightly higher than the ground level.
- After placing the plant in the hole, the soil taken out from hole previously is pressed firmly around it so that the plant is set firmly in the field. During pressing of soil, the earth ball should not be broken.
- Immediately after planting irrigation is done, the frequency of irrigation depends on the weather. Sufficient moisture should be maintained till the plants do not set or start new growth in the field.
- Regular checking of plants is essential to detect the faults like sinking of soil, tilting of plant and cracks in basin of plant after planting the grafts.

Important steps in planting of papaya

Season of planting

- Papaya can be planted year round.
- The time of planting papaya depends on several factors like climatic conditions of the place availability of irrigation facilities and consumer demands in the area.
- The best time to plant papaya in most parts of India is the beginning of the South-West monsoon in the light rainfall areas and after monsoon in the heavy rainfall areas.
**Size of seedlings for transplanting**

- Young seedlings are best transplanted because they tend to produce a better root system and do better after field planting.
- Under normal growing conditions, in about two months’ time seedlings reach to a height of 15-25 cm. Such seedlings establish successfully.
- Provide shade to the newly transplanted seedlings which can cut sun-light by 50%. This protects the seedlings from wilting before they are established.

**Planting**

- For papaya cultivation select a plot having good drainage and well protected from high winds. Before planting, clear off all the vegetation in the land and level the surface.
- Dig the pits of 45 x 45 x 45 cm at a spacing of 2.0 m X 2.0 m which can accommodate 2500 plants/hectare. Plant at 1.25 x 1.25 m, if dwarf varieties are available.
- Allow weathering for one or two weeks and then fill with top soil mix with farmyard manure or compost at the rate of 20-25 kg/pit.
- Make a small hole with a hand trowel of 15-23 cm diameter to receive the seedlings.
- As a precautionary measure, after filling the pits with pit mixture, water well in order to allow the soil to settle thoroughly before transplanting.

**Sowing of seeds**

- The most common method of propagation of papaya is from seed. Seeds germinate readily in 10 to 15 days and uniformly. Raise papaya using only good quality seed of desired variety.

**Raising of papaya seedlings**

- Different methods of raising seedlings are practiced viz., in the nursery beds, in germination trays or seed flats.
- Use polythene bags of 150 gauge for raising papaya seedlings which have been found quite satisfactory.
- Sow 250 g of seeds in the polybags to plant one hectare at a spacing of 2.0 metres either.
- In case of pot or bag sowing method, sow only 2-3 seeds per pot to compensate for poor germination and removal of male plants at the time of flowering.
• Prepare the nursery about two months prior to the scheduled date of planting. This will allow enough time for the seedlings to be ready for transplanting with a height of about 15-25 cm.

• Sow the seeds in raised beds whose surface is well pulverized and heavily manured with farmyard manure, 1-2 cm deep and 2-3 cm apart within rows spaced at 15 cm. Water the seed beds daily with a rosecan. Avoid waterlogging situations as this leads to a fungal disease called "damping off" which kills the seedlings.

Students Activities

1. Prepare a list of activities during planting of other fruit trees in your locality.
2. Visit nearby places where fruit tree planting is scheduled during rainy season and winter season in case of deciduous fruit trees, and practically carry out planting of fruit saplings.
3. Dig pits of desired size in your school farm and carry out all operations till planting of mango, papaya and citrus.

Study Material


Exercise
Mulching in fruit orchards (Plastic and Biological).

Objectives

- To learn about mulching in fruit orchards.
- To know different mulch materials used in fruit crops.

Delivery schedule: 01 periods

Student expectations/learning objectives

- To know benefits and disadvantages associated with mulching.
- To know different mulch materials having commercial value in fruit production.

Handouts/material/equipment's & tools required: Practical note book, pen, and pencil to note down the important points on mulching etc.

Pre-learning required: Pre-requisite knowledge about cultivation of fruit trees and management of fruit orchards.

Introduction

Mulch term means 'covering of soil'. Mulches are insulating substances spread over the surface of the soil. Although one of their chief purposes is the regulation of soil temperature, they serve many other functions. Mulches conserve soil moisture because they reduce evaporation by lowering the soil temperature and by increasing the absorptive capacity of the upper layer of the soil. Erosion is reduced as a result of decreased surface runoff and the shielding effect of the mulch to driving rain. Mulches may control weeds and may be a source of organic matter and nutrients for the soil. While natural mulches such as leaf, straw, dead leaves and compost have been used for centuries. The advent of synthetic materials has altered the methods and benefits of mulching. The students studying the horticulture subject must have an idea about different types of mulches used in fruit cultivation.

Types of mulches

Materials used as mulches vary and depend on a number of factors such as availability, cost, appearance, the effect it has on the soil—including chemical reactions and pH, durability, combustibility, rate of decomposition. A variety of materials are used as mulch:

1. Organic mulch: Grass clippings, leaves, hay, straw, kitchen scraps, shredded bark, whole bark, sawdust, woodchips, cardboard, wool, animal manure etc. Many of these materials also act as a direct
composting system, such as the mulched clippings of a mulching lawn mower, or other organics applied as sheet composting.

2. **Plastic mulch:** Crops grow through slits or holes in thin plastic sheeting. This method is predominant in large-scale fruits and vegetable growing, with millions of acres cultivated under plastic mulch worldwide each year. However, disposal of plastic mulch is cited as an environmental problem, for which biodegradable plastic mulch material are now a days available.

**Organic mulches**

Organic mulches decay over time and are temporary. The way a particular organic mulch decomposes and reacts to wetting affects its usefulness. Some mulches such as straw, peat and sawdust may negatively affect plant growth because of their wide carbon to nitrogen ratio, because bacteria and fungi remove nitrogen from the surrounding soil for growth. However, whether this effect has any practical impact on gardens is disputed by researchers and the experience of gardeners. Organic mulches can mat down, forming a barrier that blocks water and air flow between the soil and the atmosphere.

**Commonly available organic mulches**

**Leaves:** Fallen leaves from trees tend to be dry and blow around in the wind, so are often chopped or shredded before application. As they decompose they adhere to each other but also allow water and moisture to seep down to the soil surface. Dry leaves are used as winter mulches to protect plants from freezing and thawing in areas with cold winters.

**Grass clippings:** Grass clippings, from mowed lawns are sometimes collected and used elsewhere as mulch. Grass clippings are dense and tend to mat down, so are mixed with tree leaves or rough compost to provide aeration and to facilitate their decomposition.

**Peat moss:** Peat moss, or sphagnum peat, is long lasting and packaged, making it convenient and popular as a mulch. When wetted and dried, it can form a dense crust that does not allow water to soak in. It is sometimes mixed with pine needles to produce a mulch that is friable. It can also lower the pH of the soil surface, making it useful as a mulch under acid loving plants.

**Wood chips:** Wood chips are a byproduct of the pruning of trees. They are used to dispose of bulky waste. Tree branches and large stems are rather coarse after chipping and tend to be used as a mulch at least three inches thick. Wood chips are most often used under trees and shrubs.

**Bark chips:** Bark chips, of various grades are produced from the outer corky bark layer of timber trees. Sizes vary from thin shredded strands to large coarse blocks. The finer types are very attractive but have a large exposed surface area that leads to quicker decay. Layers two or three inches deep are usually used.

**Straw mulch:** Straw mulch or field hay are light weight biodegradable and neutral in pH. They have good moisture retention and weed controlling properties but also are more likely to be contaminated with weed seeds. Straw mulch is also available in various colours.

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For teachers…

- Ask students to practically examine different types of mulch materials.
- Practically show different types of mulch in fruit nurseries and orchards.
- If possible ask students to...
Plastic mulch

Dr. Emery M. Emmert of the University of Kentucky was one of the first to recognize the benefits of using LDPE (low density polyethylene) and HDPE (high density polyethylene) film as mulch in horticultural production. Today, Dr. Emmert is considered the "father of plastic greenhouses". LDPE, HDPE and flexible PVC have all been used and although there were some technical performance differences. Owing to its greater permeability to long wave radiation which can increase the temperature around plants during the night times, polyethylene is preferred. Today the vast majority of plastic mulch is based on LLDPE because it is more economic in use.

Basic properties of mulch film

a. Air proof so as not to permit any moisture vapour to escape.

b. Thermal proof for preservation of temperature and prevention of evaporation.

c. Durable at least for one crop season.

Important parameters of the plastic film

Thickness: Normally the thickness of the film does not affect the mulching effect except when it is used for solarisation. Since it is sold by weight it is advantageous to use as thin a film as possible but at the same time due consideration should be given for the longevity of the film. The early mulch films used were of 60-75 micron (240-300 gauge) thickness, and today it is possible to have 15 micron thick film.

Width: This depends upon the inter row spacing. Normally a one to one and half meter width film can be easily adopted to different conditions.

Perforations: The perforations may be advantageous under some situations and disadvantageous for some other situation. The capillary movement of water and fertilizer distribution will be better and more uniform under unperforated condition. Prevention of water stagnation around the plants, perforation is better. But it has got the disadvantages of encouraging weed growth.

Mulch colour: The colour of the mulch affects soil temperature, temperature of air around the plants and soil salinity. In fruit production black, transparent and silver coloured plastic mulches are commonly used. Transparent film deposits more salt on soil surface however black film restricts water movement and upward movement of salt is reduced.
**Selection of mulch**

The selection of mulches depends upon the ecological situations and primary and secondary aspects of mulching.

- **Rainy season** - Perforated mulch
- **Orchard and plantation** - Thicker mulch
- **Soil solarisation** - Thin transparent film
- **Weed control through solarisation** - Transparent film
- **Weed control in cropped land** - Black film
- **Sandy soil** - Black film
- **Saline water use** - Black film

**Methods of mulching in orchards/established trees**

- Mulching area should preferably be equivalent to the canopy of the plant.
- Required size of mulch film is cut from the main roll.
- Clean the required area by removing the stones, pebbles, weeds etc.
- Till the soil well and apply a little quantity of water before mulching.
- Small trench could be made around the periphery of the mulching area to facilitate anchoring of the mulch film.
- Cover the film to the entire area around the tree and the end should be buried in the ground.
- Semi circular holes could be made at four corners of the film in order to facilitate water movement.
- The position of the slit/opening should be parallel to the wind direction.
- Cover the corners of the film with 4-6 inches of soil on all sides to keep the film in position.
- In hard soil, make a trench of 1’x1’x2’ depth on four corners of the mulching area and fill it up with gravel or stones, cover the trenches with the mulch film and allow the water to pass through the mulch to the trenches via semi circular holes on the film.
- Mulch should be laid on a non-windy condition.
- The mulch material should be held tight without any crease and laid on the bed.
- The borders (10 cm) should be anchored inside the soil in about 7-10 cm deep in small furrows at an angle of 45°.
**Students Activities**

1. Visit local fruit nurseries and orchards and note down the types of mulches used there.
2. Practically lay locally available organic mulch or plastic mulch in fruit orchards, if possible.
3. Examine different types of organic and plastic mulches and note down in the note book.

**Study Material**

PERFORMING INTERCULTURAL OPERATIONS IN ORCHARDS

Exercise
Performing intercultural operations in orchards.

Objectives
- To know about different cultural operations in fruit orchards

Delivery schedule: 01 period

Student expectations/learning objectives
- To know about necessity of intercultural operation in orchards.
- To acquire skill of performing intercultural operation in fruit orchards.

Handouts/material/equipment’s & tools required: Practical note book, pen, and pencil to note down the important points on intercultural operations etc.

Pre-learning required: Pre-requisite knowledge about cultivation of fruit trees and management in fruit orchards.

Introduction
Intercultural operation are those activities which are performed in the fruit orchards for improving sanitary conditions, controlling weeds, providing nutrition to the trees, growing intercrops, irrigation, green manuring, mulching pruning and training, fruit thinning and management of insect pest and diseases. Factors responsible for the decline of fruit yield and proper fruiting pattern mostly pertains to poor management practices. It is therefore imperative to pay attention for timely execution of intercultural operation in order to keep fruit trees in the orchard in healthy condition. Practical knowledge of several intercultural operations in fruit orchards is a requisite for successful growing of fruit trees. Important intercultural operations generally followed in some commercial fruit crops are given hereunder.

Intercultural operation in apple orchards

Weed control: The young apple tree are vulnerable to competition for nutrient from the weeds. Weeding should be done at regular intervals during the initial years. Apart from hand weeding use of herbicides to eliminate weeds both in the nursery as well as in the field is practical. In the apple orchards

For teachers…
- Ask students to practically observe and make a schedule of different intercultural operation in fruit orchards in the locality.
- Ask students to make schedule of intercultural operation in other fruit crops as per their cultural requirements.
pre- and post-emergence application of Atrazine (2-6 kg/ha) controls the weed population. Mulching followed by herbicide application is the most effective method of controlling weed. The best time of application of these herbicides is early in the spring.

**Mulching:** Mulching with straw, hay, sawdust, oak leaves or other organic matter increases the humus content of the soil and its moisture holding capacity. Various plastic and polythene mulches are used. Black polythene mulch in cooler climatic conditions is very effective. It also helps in reducing fruit drop and improve fruit size, colour and quality.

**Pruning:** Pruning is done with a view to divert the sap flow towards the fruiting branches and to force the plants to bear more fruits or to induce vigorous vegetative growth. During pruning, weak-growing and diseased branches are removed from the tree. Usually the trees are pruned every year in the month of December-January. The systems of pruning adopted in apple cultivation are different for different purposes. For established spur system, the objective of pruning is to develop permanent fruit spurs for production of fruits. To ensure formation of spurs on the laterals the central leader is cut back every year along with the strong erect laterals near the central leader. This leads to wide angled laterals for formation of spurs. Similarly in case of regulated system, pruning is practiced on apple cultivars growing on semi-dwarfing and vigorous rootstocks. Before planting, the central leader of the tree is cut back at 75 cm on which three well placed primary branches are allowed to grow. In bearing trees, the growth of leader and strong laterals are encouraged by pruning weak and crowded branches. For renewal system in vigorous cultivars instead of developing permanent spurs, the objective is to encourage continuous growth of new healthy shoots, spurs and branches every year. A part of the tree is pruned every year to produce fruits in the following year on the new shoot growth, while the unpruned parts produces fruit buds.

**Thinning of fruits:** Thinning is one of the major techniques to improve fruit quality. In apples, heavy bearing not only results in small-sized poor quality fruits but also sets in alternate bearing cycle. Judicious thinning done at the proper stage of fruit development can regulate cropping and improve fruit size and quality. Since manual thinning is cumbersome and expensive, chemical thinning is advised.

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Dose (ppm)</th>
<th>Stage of application</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAA</td>
<td>10-15</td>
<td>Full bloom to 4 weeks after petal fall</td>
</tr>
<tr>
<td>2,4-D</td>
<td>2-10</td>
<td>Full bloom to petal fall</td>
</tr>
<tr>
<td>2, 4, 5-T</td>
<td>2-2.5</td>
<td>Full bloom to petal fall</td>
</tr>
<tr>
<td>Carbaryl (Sevin)</td>
<td>1000-2000</td>
<td>Petal fall and 4 week after petal fall</td>
</tr>
</tbody>
</table>
Intercultural operations in mango orchards

**Weed control:** Immediately after planting the mango, the excessive population of weed should not exist. Hoeing should be done depending on weed growth in the basin. The area between the basins should be ploughed at least three times a year, i.e., pre-monsoon, post-monsoon and in the last week of November.

**Intercropping:** During initial years of planting, crops like green gram, black gram, vegetable crops such as cabbage, cauliflower, potato, brinjal, cucumber, pumpkin, tinda etc. and spices like chilies can successfully be grown as inter crops. The partial shade loving crops like pineapple, ginger, turmeric, etc. can be grown in fully grown orchards. In addition to field crops, some short duration, less exhaustive and dwarf type inter fillers like papaya, guava, peach etc. can also be grown with the main mango crop.

**Pruning:** Normally, mango trees do not require frequent pruning. However, the training of the plants in the initial stages is very essential to give them adequate shape. Training becomes very important especially when the branches are placed at a low level. Therefore at least 75 cm of the main stem should be kept free from branches and the first leader/main branch is allowed to grow. The main branches should be spaced in such a way that they grow in different directions and are at least 20-25 cm apart. The branches, which exhibit tendency of crossing and rubbing each other, should be removed in the pencil thickness stage. Subsequently pruning is done only to remove the diseased and dead branches.

**Students Activities**

1. Visit local fruit orchards and make a schedule of intercultural operations practiced there.
2. On the basis of cultural requirement of other fruit crops available in the locality prepare schedule of different month wise cultural operations.

**Study Material**

Exercise
Selecting at least two fruit species and maintaining them from flowering to fruiting.

Objectives

- To know about different cultural operations from flowering to fruiting in two fruit species.

Delivery schedule: 02 periods

Student expectations/learning objectives

- To know about management operations in fruit orchards during flowering and fruiting.
- To acquire skill of performing cultural operation in fruit orchards.

Handouts/material/equipment's & tools required: Practical note book, pen, and pencil to note down the important points on cultural operations from flowering to fruiting.

Pre-learning required: Pre-requisite knowledge about cultivation of fruit trees and management in fruit orchards.

Introduction

The main aim of growing fruit trees is to obtain good quality nutritious fruits. These fruits may be consumed fresh or sold in the local or distant markets. The flowering is an important developmental phase of fruit trees which decides the productivity of fruit trees. Management of fruit trees during flowering and fruiting is very important. Various cultural operations like irrigation, fruit drop control measures, control of diseases and insect pests, weeding, nutrition are important to realize better harvest of quality fruits.

It is expected from the horticulture students that they should know different cultural operations during flowering and fruiting in commercially grown fruit trees of the locality. In the present practical examples are given for mango and apple orchards. Students can prepare their own schedule of operations during flowering and fruiting in other fruit species grown in the locality.

Cultural operations during flowering and fruiting (Mango)

Stage 1

- Chemical control of diseases, if symptoms are seen.
• Need not to irrigate trees during flowering.

• No insecticide sprays to control insects. This may kill beneficial insects like honey bees etc. which help in pollination.

• Try to keep basin near tree trunk free from weeds.

• Keep honey bee boxes in the fruit orchard from better pollination.

**Stage 2**

• Irrigate fruit trees at weekly intervals.

• Spray plant growth regulators like NAA, 2,4-D etc., for control of fruit drop.

• Application of fertilizers as per requirement.

• Chemical control of diseases (powdery mildew, anthracnose), if symptoms are seen.

• Chemical control of insects and pests (mango hopper, mealy bug etc.).

• Keep basin near tree trunk free from weeds.

**Stage 3**

• Irrigate at regular intervals for better fruit growth.

• Spray of micronutrients (Zn, Fe, B, Mn etc.) to minimize fruit disorders.

• Chemical control of disease (powdery mildew, anthracnose etc.), if symptoms are seen.

• Chemical control of insect and pests (mealy bug, mango hopper etc.).
Stage 4

- Harvesting of mature fruits on the basis of harvest indices recommended.
- Washing of fruits and pre-cooling to remove field heat.
- Grading of fruits in different class on the basis of size, shape and colour.
- Ripening of fruits using ethylene chambers ethrel solution.
- Packaging of fruits for marketing.

**Cultural operations during flowering and fruiting in citrus**

Stage 1

- No insecticide sprays to control insects. This may kill beneficial insects like honey bees etc. which help in pollination.
- Aphid and leaf minor infestation is common at this stage. Soil application of phorate insecticide can be done to control aphids.
- Need not to irrigate until fruit set.
- Try to keep basin near tree trunk free from weeds.
- Keep honey bee boxes in the citrus orchard from better pollination.

Stage 2

- Irrigate fruit trees at weekly intervals.
- Spray plant growth regulators like NAA, 2,4-D etc. for control of fruit drop.
- Application of fertilizers as per requirement.
- Cultural and chemical control of insects and pests (mealy bug, sucking moth etc.).
- Try to keep basin near tree trunk free from weeds.
Stage 3

- Irrigation at regular intervals for better fruit growth.
- Spray of micronutrients to minimize fruit disorders.
- Chemical control of diseases (phytophthora, citrus canker etc.), if symptoms are seen.
- To avoid fruit cracking, ensure regular water supply and arrange for borax or potassium sulphate or gibberellins spray.
- Spray 2,4-D or NAA to control pre-harvest fruit drop.
- Try to keep basin near tree trunk free from weeds and avoid water stagnation near tree trunk.

Stage 4

- Harvesting of mature fruits on the basis of harvest indices like colour development or TSS: acid ratio.
- Cleaning of fruits.
- Grading of fruits in different classes on the basis of size, shape and colour.
- Packaging of fruits for marketing.

Students activities

1. Select two fruit species grown in your locality and make a schedule of cultural operations (as per exercise table 1) practiced from flowering till fruiting.
Study material


Exercise Table 1.

<table>
<thead>
<tr>
<th>Fruit species</th>
<th>Flowering Duration</th>
<th>Fruiting Duration</th>
<th>Disease(s) observed</th>
<th>Disease(s) control measures adopted</th>
<th>Insect/pest infestation observed</th>
<th>Insect control measures adopted</th>
<th>Micronutrient spray details</th>
<th>Plant growth regulators spray details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Exercise
Training and pruning in available fruit trees.

Objectives

- To know about training of fruit trees.
- To know about pruning of available fruit trees.

Delivery schedule: 01 period

Student expectations/learning objectives

- To acquire skill of training of important fruit trees in the locality.
- To acquire skills of pruning of important fruit trees.

Handouts/material/equipment's & tools required: Practical note book, pen, and pencil to note down the important points on training and pruning operations etc., secateurs, Bordeaux paste, small handle saw.

Pre-learning required: Pre-requisite knowledge about training and pruning of fruit trees.

Introduction

Training and pruning are an age old horticultural practices in fruit trees for canopy management. This forms the basis of precociousness and longevity of the fruit trees in an orchard. The strong scaffold system helps the trees to produce heavy crop load of quality fruits without any major limb breakage. Similarly, regular annual pruning provide the tree the maximum fruit bearing area uniformly over the whole tree. Unpruned trees grow beyond limits and branches start intermingling with the branches of adjacent trees. It is therefore imperative to train fruit trees in its initial years of establishment and regularly prune the tree for more yield of better quality of fruits. Students should know the basic principles behind training and pruning of fruit trees and should acquire the skill of training and pruning of fruit trees available in the locality.

Principles of training and pruning of fruit trees

Training of plants is shaping or adapting them to specific forms so that they can function more efficiently or effectively. Training includes tying, fastening, staking or supporting over a trellis or pergola in a certain fashion or some of its parts are removed to provide a specific framework. A primary objective of training is to develop a strong and open tree framework that allows enough light to reach inside the canopy. Opening the tree canopy also permits adequate air movement through

For teachers...

- Ask students to perform training operation on newly established fruit trees.
- Ask students to perform heading and thining out operation on fruit trees.
the tree. Additionally, a well-shaped fruit tree is aesthetically pleasing, whether in a garden, or commercial orchard. There are many ways to train fruit trees – no single method is right for all situations and needs. Following training systems are generally followed for canopy management of fruit plants in different regions.

**Open center or vase system:** In this system, the main stem is terminated and growth is forced through a number of branches originating rather close to the upper end of the trunk. In regions where sunlight is a limiting factor, vase or open center systems are generally preferred. In fruit crops like peach and plum this system is commercially followed.

**Central leader system:** In this system, the trunk is encouraged to form a central axis with branches distributed laterally up and down and around the stem. The central axis, or leader, is the dominant feature of the trees framework, and the main direction of growth is upward. In fruit crops like pear, some varieties of apple, plum, apricot, cherry, walnut and pecan nut this system is occasionally followed.

**Modified leader system:** The modified leader system is somewhat intermediate between open central and central leader systems. The central leader is allowed to grow for four five years and then it headed back and lateral branches are allowed to grow as in the open central system. Apple, walnut, pears, guava and fig etc. are usually rained by this system. This system promotes the lateral shoot growth and restricts the upright growth of the plant by checking the apical dominance.

Unfortunately, many people approach pruning with a great deal of apprehension. Others view pruning as a chore and give little forethought to technique as they hastily do the job. Proper pruning requires a basic understanding of how plants respond to various pruning cuts. Pruning is an operation based on scientific
principles to improve the overall performance of fruit trees. The growth and flowering habits of specific variety must be taken into account for deciding the nature and extent of pruning. Pruning involves both art and science: art in making the pruning cuts properly, and science in knowing how and when to prune for maximum benefits. There are two basic types of pruning cuts, heading and thinning.

Each results in a different growth response and has specific uses. Heading consist of cutting back the terminal portion of a branch to a bud, whereas thining out is the complete removal of a branch to a lateral or main trunk. Because the heading back of a stem destroy apical dominance, it is usually followed by the stimulation of several lateral bud break, depending on the species and the distance from the tip to the cut. To encourage spreading growth, the branch is usually cut back to an outward-pointing bud. Heading back tend to produce a bushy, compact plant. Other types of heading are topping, dehorning, hedging and clipping. Thinning in contrast to heading encourages longer growth of the remaining terminal branches. The net result of thinning is a reduction of laterals. Thinning of weak growth tends to open up the tree. It usually results in producing a larger rather than bushier plant. Thinning is generally the least invigorating type of pruning cut and provides a more natural growth form of plants. Important in maintenance pruning, thinning cuts are used to shorten limbs, to improve light penetration into plants and to direct the growth of shoots or limbs.

Pruning and bearing habit of fruit trees

The amount of pruning depends on the bearing habit of the plant. One should be thoroughly familiar about the bearing habit of fruit trees to prune them meaningfully and profitably. Different varieties of fruit trees differ in their position of flower bud differentiation. Buds having the potential to flower are formed either terminally, laterally or adventitiously. The terminal bud may be formed on long or short growth, laterally on current or past season growth and adventitiously from any point on the trunk. Plants having terminal fruit bud do not possess exactly spreading habit and the trees are rather compact or bushy. Similarly, plants possessing flower buds on the spurs (terminally as in apple and laterally as in sweet cherry) are more compact than those bearing fruit buds on long shoot. Depending on the position of the flower buds developing into a fruit, the grower has to use light, medium or heavy pruning.

Timing of pruning

The time of pruning is influenced by a number of factors, including convenience, the peculiarities of species, and the effect desired. Fruit trees are usually dormant pruned. Not only is this most convenient in the cycle of orcharding, but the framework of the plant can be more easily seen with the foliage off. Where winter temperature are low, pruning operation is usually delayed until the severest weather is past in order to reduce winter injury to fresh cuts. The pruning operation is best not carried on into the growing season because of the additional loss of translocated foods.

Students Activities

1. Visit newly established fruit orchards in the locality and train few trees in open central system and few in modified leader system.
2. Practice thinning out and heading types of pruning on some fruit trees in the locality.
3. Practice removal of dead wood, intermingling branches, water suckers, root suckers and diseased shoots from the fruit trees.
Study Material


Exercise
Training in grape on head and bower systems, if available.

Objectives

- To learn about training of grape vines on head and bower systems.

Delivery schedule: 01 period

Student expectations/learning objectives

- To learn training of grape vines on head system for high productivity and fruit quality.
- To learn training of grape vines on bower system for high productivity and fruit quality.

Handouts/material/equipment's & tools required: Practical note book, pen and pencil to note down the important points on training systems of grapevine. Secateurs, grafting knife, aluminum tags and other item required for performing training on grape vines.

Pre-learning required: Pre-requisite knowledge about training of fruit crops and its importance in fruit production.

Introduction

Naturally, grape vine is a slender climber clinging with the help of tendrils and bearing scanty fruits at the top. To domesticate grapevines, channelizing its energy from vegetative growth to enhanced bearing, an artificial support is a must. In fact, improper training may lead to complete barrenness of the grapevine. In grape training is a distinct process and numerous systems have been evolved to create microclimate to manipulate the physiology of grape vines for increased production and improved berry quality. The basic objective of training grape vines is to give desired shape that maintains its vigour for a long time and facilitate requisite leaf exposure and cultural operations. Grapevines generally bears on new season growth which emerge from the previous season mixed buds. Grapevines can not be grown satisfactorily without some form of support, temporary or permanent, to obtain a well formed vine with a strong strait trunk quickly and economically. Various form of support like, bowers (arbours), stakes and trellis have been devised. The sort time support or stakes, especially in hard pruned vines provide support until the vines are large and rigid enough to stand on their own. The permanent support, bowers and trellis are required for vines that are either cane-prunned or cordon-trained.

Bower system of training

Bower is consisting of a criss-cross network of wires usually 2.5 meters above ground supported by pillars

For teachers…

- Make students to understand the difference between training and pruning of grape.
- Practically show the different systems of training in grapevines to the students, if
made of concrete, stone, iron angle or bamboo. The training of grapevine on bower is done to form two major limbs on which several cordons are developed one on either side of each limb running along each wire. This is most popular system of grape training. The two primary limbs are developed bi-directionally and the secondary cordons are developed on the main arms so that the vines covers the over head area of about 9 square metres when planted at 3.0 m x 3.0 m. Short or long fruiting spurs are allowed to develop on the secondary cordons only. The formation of two primary limbs is encouraged by pinching off the apical shoot close to the wire. Two vigorous shoots growing in opposite directions are selected at the wire level for training as primary arms. One secondary limb is allowed to develop along each wire from these two primary. Generally, the entire length of primary arms is attained in two years. In three meters, there are usually eight wires and, therefore, eight secondary cordons should be developed on either sides, i.e. approximately four on either side of primary cordon. Once the primary and secondary cordons have been developed, the rest of the pruning is similar to that on any other cordon system.

**Head system of training**

In this system grape vines are allowed to grow single stem initially upto a height of 1.0-1.2 m. Although, initial support are provided by means of bamboo or wooden poles which are subsequently withdrawn. As a result, the trunk of the climbers support their own canopy without any artificial framework. The tip of the grapevine is trimmed to a specific height and allowed to grow four well spaced laterals in four directions to keep balance and avoid crowding of laterals, upto a distance of about 0.7-0.8 m and again the apex of the laterals are trimmed to form bushes. This is one of the chepest methods of training grapevines.

**Students Activities**

1. Visit to a vineyard in its initial stage of establishment and attempt training of the grapevines with the help of trained personnel.
2. Write down the sequential steps involved in training of grapevines.
3. Make attempt to train other fruit plants of your locality.

**Study Material**


Exercise
Training in mango and pomegranate.

Objectives

- To learn how to train a mango and pomegranate tree in the initial years of establishment

**Delivery schedule:** 01 period

**Student expectations/learning objectives**

- To know how to train a mango tree for the development of a strong framework

- To learn how to train a pomegranate tree for the development of a strong framework

**Handouts/material/equipment’s & tools required:** Paper sheet and pen to note down the different training systems in mango and pomegranate, if any, and some equipments and other material required for training of trees.

**Pre-learning required:** Pre-requisite knowledge about training of fruits, and its importance in fruit production.

**Introduction**

Training is an operation done to a plant by which it is made to develop a sound framework or structure that facilitates free air movement, and ease in cultural practices. It is necessary to pay sufficient attention for training of plants during the first few years of planting. During this period, the pre-planned framework as decided by the grower should be allowed to develop. The main points to be kept in view while training are:

- To admit adequate sunlight and air to the center of the tree and to expose maximum leaf area to the sun.

- To limit the growth and spread of the tree so that various cultural operation such as spraying and harvesting are performed at a minimum cost.

- To build the framework and arrangement of scaffold branches.

- To build the structure of the tree in such height at which the trees are less exposed for sunscald and wind damage.

Before thinking of training of any tree, one should decide the height of the head or crown. Depending upon the height of the crown from ground level, the plants can be grouped in two: high head and low head.

**Training of mango trees**

Mango being evergreen, plant requires very little training and pruning. However, training of young plants is
necessary, which should be done in early years of planting by removing side branches up to the height of one metre from the ground level and side branches are allowed to grow beyond one metre height. Such type of initial training provides good architecture of the plant and it is helpful in good fruit production. Most of the cultivars of mango grow erect, from a natural dome shape canopy and having symmetrical branching need only occasional pruning. However, in general, dead, diseased or criss-cross branches are pruned but severe pruning is needed only in high density of Dushehari mango. This pruning is done just after crop harvest and it is also called as summer pruning. In this pruning, every shoot is cut back 2-3 cm from growing point followed by spray of 1% urea and 0.1% copper oxychloride on pruned mango trees.

For high density planting of Amrapali, special training tips have been recommended. In this, it is advisable to train the plant to a bush. This is done by 'pinching off' the terminal vegetative growth in the first and 2nd year of planting to encourage formation of branches. Afterwards, the tree is maintained dwarf by regular bearing habit of the variety.

Training in pomegranate

Because pomegranate suckers profusely from the crown, frequent sucker removal will be necessary to train the plant into a tree form. The process must be started soon after planting to maintain a single trunk, otherwise too many suckers will be developed and later it will be difficult to change. Unless there is a strong desire for a tree-form, the bushy, free-growing shrub develops naturally.

Hence, at planting, reduce each plant to a single stem and shorten this to about 50 cm above ground level. A short stake may be needed for support until the stem becomes rigid and sufficiently strong. Subsequently, select three to five shoots arising from the

For teachers…
- Make students to understand the difference between training and pruning and is the importance of these two terms in the fruitful production of fruits.
- Practically, show the students, the different activities or practices required during training of mango and pomegranate.

A sketch for training of mango in the initial years of establishment

Well trained pomegranate trees / bushes

A view of excellent bearing in pomegranate tree
upper half of the stem to provide the main framework. These will be shortened at each winter pruning to produce a strong compact frame. Several secondary limbs should be allowed to develop from each main limb, but excessive numbers which would lead to over crowding should be removed, as should any suckers which develop from the base of the tree. Pruning of the fruiting pomegranate tree consists of mainly removal of excessive over crowded growth, dead wood and suckers. Adequate fruit-bearing wood should be retained. This will be mature growth 2 to 3 years old from which short flower-producing spurs arise.

**Students Activities**

1. Go to a mango and pomegranate orchards which have been in their initial year of establishment and attempt training of the plants with the help of a trained personnel. Make a list of operations required for training of fruit plants.

2. Make attempt to train other fruit plants of your locality.

3. Learn pruning and prune the fruit plants which are in your locality.

**Study Material**


NOTCHING AND PRUNING IN FIG

Exercise
Notching and pruning in fig.

Objectives

- To know about pruning and notching effects & on flowering and fruiting in fig.

Delivery schedule: 01 period

Student expectations/learning objectives

- To know how to prune fig
- To know notching technique for activation of dormant buds in fig.

Handouts/material/equipment's & tools required: Practical note book, pen, and pencil to note down the important points. Secateurs, pruning knife etc. for performing notching and pruning in fig.

Pre-learning required: Pre-requisite knowledge about different crops of fig and dormancy and growth of fig plants.

Introduction

Fig is a deciduous plant but does not require chilling to break dormancy. In North India, it remains dormant during winter and puts up new growth with the advent of spring season. However, in Western India, during monsoon (August-September) it becomes dormant and puts up new growth in October. The main objective of pruning in fig is to induce growth of flower-bearing wood and thereby improve the yield of fruits. In addition, pruning increases the fruits weight in early varieties. Besides pruning, certain other methods such as notching are also adopted to stimulate production of laterals on vigorous upright branches. Notching in the form of a slanting cut is given a little above the buds, removing a slice of bark. A combination of notching and pruning has been found to accelerate more laterals and induce more fruits on the new growth than by pruning or notching alone.

Pruning in fig

- Fig trees are pruned annually and trained to a desired height to keep the plants more productive and to facilitate harvesting and other orchard operations.
- In northern India, trees are headed back to a height of 30 cm or 45 cm. whereas in Pune heading back to about 1-1.5 m, is usually done.
- As the fig tree normally bears 2 crops in a year, the first (known as breba) on the wood of previous season and the second crop on new wood of current season, the time and amount of pruning is adjusted according to the growth habit and bearing capacity of the tree.

- In Pune, light pruning is given just after the crop has been harvested. In Uttar Pradesh severe pruning is given in December, leaving only 3 to 4 buds in shoots of previous years growth. In Karnataka, the fig plants are headed back every year in January-February to about 2 buds on each shoot of previous season's growth to obtain fruits in July-October.

- Some growers prefer to prune the tree in October to get fruits in the following summer. In contrast, little or no pruning is done in Tamil Nadu.

**Notching in fig**

- Notching in the form of a slanting cut is given a little above the buds, removing a slice of bark.

- Notching is also adopted to stimulate production of laterals on vigorous upright branches.

- A combination of notching and pruning has been found to accelerate more laterals and induce more fruits on the new growth than by pruning or notching alone.

- The depth and width of the notch varies according to the size of the branch.

- Notching is done in July on at least 8 months old shoots. It has been found that the lower most 3-4 buds at the basal end of the branch are too dormant to be activated, but the buds on the middle portion of the mature shoot can be successfully activated. It is recommended the only 1 or 2 buds on such shoot be activated by notching.

**Students Activities**

1. Perform pruning and notching operations on fig plants during dormancy.
2. Observe effect of pruning and notching on emergence of new growth and activation of dormant buds.
Study Material


Exercise
Foliar application of nitrogenous fertilizers in fruit crops.

Objectives

- To learn the benefits of foliar application of nitrogenous fertilizers in fruit crops

Delivery schedule: 01 period

Student expectations / learning objectives

- To know what is foliar application
- To learn the foliar application methods
- To learn how the nitrogenous application can be beneficial to fruit crops

Handouts / material / equipment's & tools required: Paper sheet and pen to note down the different types of fertilizers, water soluble fertilizer, buckets, small sprayers and gloves.

Pre-learning required: Pre-requisite knowledge about foliar applications and its importance in fruit production.

Introduction

Plants require nutrients for better growth and development. The nutrients normally available to plants from soil. The nutrients will be available in a slow manner. There are other methods of application that can increase the efficiency of nutrient availability to the plants. These are fertigation and foliar application. Foliar application is the process where the fertilizers are dissolved in water and such diluted solutions are sprayed directly on the plants foliage, either through a hand operated sprayers for individual trees or for a small holdings or through a tractor drawn high volume sprayers for medium farms or by means of aircrafts for foliar spray on large scale.

The main points to be remembered

- Foliar application of nitrogenous fertilizer in order to supplement a part of their nutritional requirement.
- Foliar application of nitrogenous fertilizer helps to rectify the nitrogen deficiency quickly.
- Mostly urea is used as nitrogen sources for foliar application.
• Normally foliar applications are given at a very low concentration. However in special cases such as to regulate a crop or to defoliate for a specific reason higher concentration (5-10 percent) of urea can be used.

• Spraying of foliar nitrogen early in the morning will be ideal.

• Avoid spraying on windy days, mid-day or rainy day.

• Water-soluble formulations generally work better for foliar applications as they are easily dissolved in water.

Before thinking of foliar spray of nitrogenous fertilizers, one should also decide the type of fertilizers to be used, at what concentration, the crops to be sprayed upon, the season and time of spraying.

**Foliar application of nitrogenous fertilizers**

We should know the different nitrogenous fertilizers suitable for foliar spray. Some of them are presented in the table.

<table>
<thead>
<tr>
<th>Name of Fertilizers</th>
<th>Nitrogen Content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biruet free urea</td>
<td>21.0-44.0</td>
</tr>
<tr>
<td>Ammonium polyphosphates</td>
<td>10.0-21.0</td>
</tr>
<tr>
<td>Orthophosphates (liquid)</td>
<td>3.0-16.0</td>
</tr>
<tr>
<td>Calcium Nitrate</td>
<td>15.0</td>
</tr>
<tr>
<td>Potassium Nitrate</td>
<td>13.75</td>
</tr>
<tr>
<td>Ammonium thiosulfate</td>
<td>12.0</td>
</tr>
<tr>
<td>Ammonium sulfate solution</td>
<td>8.0</td>
</tr>
</tbody>
</table>

**Nitrogen materials**: Urea is the most suitable nitrogen source for foliar applications, due to its low salt index and high solubility in comparison to other nitrogen sources. However, the urea utilized in foliar sprays should be low in biuret content as it reduces the foliage burning symptoms. Other sources of nitrogen are listed in the table. A relatively new nitrogen compound, Triazone®, which was developed in the late 1970's, has ideal uses in foliar applications due to its low-burn characteristics.
Steps involved in foliar applications

- Select a water soluble nitrogen fertilizers, for example urea
- Weigh required quantity of fertilizer for spraying. The quantity of urea may vary depending upon the concentration of the solution and the spray volume to be sprayed. For example, the concentration of spray solution is 0.1% urea and the spray volume is 100 litres of water, now the quantity of fertilizer needed for spraying is 100 g (1 g in one litre = 0.1 %, therefore for 100 litre , you multiply with 100 that 100 x 1 g = 100 g
- Dissolve the known quantity of fertilizer in the water and stir it until the fertilizer gets completely dissolved. Now this solution is called as the nitrogenous spray solution
- Add some wetting agent like soap solution or tepol in order to get sticky to the leaf surface for longer period
- Fill the solution in the sprayer of your availability (hand sprayer or foot sprayer or tractor mounted power sprayer)
- Spray operation should be done either early in the morning or in the late evening
- Take precaution while spraying like covering the face with mask and wear proper gloves
- The sprayer should be cleaned after every spraying operation

Students Activities

1. Make attempt to train yourself for making water soluble fertilizers solutions.
2. Make a list of materials required for spraying.
3. Visit to a fruit orchard which is near to the school and attempt to apply the nutrients through foliar method.

Study Material

Exercise
Manuring with farm yard manure and chemical fertilizers in fruit crops.

Objectives

- To know about use of manures and chemical fertilizers in fruit crops
- To know about different chemical fertilizers as commercial source of nutrients

Delivery schedule: 01 period

Student expectations/learning objectives

- To know how to apply manures and chemical fertilizers in fruit crops.
- To know time of application of manures and fertilizers in fruit crops.

Handouts/material/equipment's & tools required: Practical note book, pen, and pencil to note down the important points related to application of FYM and fertilizers in fruit crops.

Pre-learning required: Pre-requisite knowledge about important nutrients and their role in plant growth and development.

Introduction

In addition to water, sunlight, and carbon dioxide from the air, plants require 13 mineral nutrients that are typically derived from the soil. The macronutrients nitrogen (N), phosphorus (P), potassium (K) are needed by plants in relatively large amounts and often have to be added to the soil. Intermediate amounts of secondary nutrients magnesium (Mg), calcium (Ca), and sulphur (S) are needed by plants. Trace or micronutrients [boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo) and zinc (Zn)] are needed in small amounts. Manures and fertilizers are materials that contain nutrients required by plants. Plants cannot differentiate between nutrients from organic, inorganic, liquid or granular sources. All nutrients are absorbed by plant roots as ions and all ions of a given element are identical regardless of the source. Fertilizers can be applied to the soil and taken up by the roots or applied to the plant as a liquid for uptake by the leaves, stems or fruit (foliar application). Soil application is usually less expensive and is better suited for large application rates of the major nutrients and for pre-plant application. For the most part, soil applications by broadcasting is the most economical and efficient method. Foliar application is best for correcting micronutrient deficiencies.
Chemical composition of manures and important commercial fertilizers

Farm yard manure: This is the traditional manure and is mostly readily available to the farmers. Farm yard manure is a decomposed mixture of Cattle dung and urine with straw and litter used as bedding material and residues from the fodder fed to the cattle. The waste material of cattle shed consisting of dung and urine soaked in the refuse of the shade is collected daily and placed in trenches. It becomes ready to apply after 3-4 months. Well rotten farm yard manure contains 0.4 to 1.5 % N, 0.3-0.9 % P$_2$O$_5$, and 0.3-1.9% K$_2$O.

Fertilizers: Inorganic fertilisers are chemicals, which provide plant-food in ample quantities. Fertilisers also have the advantage of smaller bulk, the resultant easy transport. Inorganic fertilizers are grouped into nitrogenous fertilisers, phosphatic fertilisers, potassic fertilisers and soon.

<table>
<thead>
<tr>
<th>Nitrogen</th>
<th>N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea</td>
<td>46</td>
</tr>
<tr>
<td>Ammonium sulphate</td>
<td>21</td>
</tr>
<tr>
<td>Prilled ammonium nitrate</td>
<td>34</td>
</tr>
<tr>
<td>Ammonium nitrate/calcium carbonate</td>
<td>21-26</td>
</tr>
<tr>
<td>Anhydrous ammonia</td>
<td>81</td>
</tr>
<tr>
<td>Liquid fertilizers containing ammonium nitrate, ammonia and urea</td>
<td>20-40</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phosphorus</th>
<th>P$_2$O$_5$(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superphosphate</td>
<td>18-21</td>
</tr>
<tr>
<td>Triple superphosphate</td>
<td>45-47</td>
</tr>
<tr>
<td>Ground mineral phosphate</td>
<td>29-33</td>
</tr>
<tr>
<td>Basic slag</td>
<td>8-22</td>
</tr>
<tr>
<td>Diammonium phosphate</td>
<td>46+18 (Nitrogen)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Potassium</th>
<th>K$_2$O (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium chloride (muriate of potash)</td>
<td>60</td>
</tr>
<tr>
<td>Potassium sulphate</td>
<td>50</td>
</tr>
</tbody>
</table>

Method of manures application

The methods of applying manures would depend on the type of manure, i.e. i) Bulky manures and ii) Concentrated manures.

Bulky manures like Farm Yard Manure should be broadcast over the entire area and mixed well with the soil by harrowing. The season of application should be such that the manure is not leached out. In heavy rainfall areas, the manures may be applied after the monsoon; whereas in light rainfall areas, manures can be applied during monsoon.

The Concentrated Manures include organic manures such as oil cakes, blood and bone meal etc. The nutrients in the manures are not available quickly, as they have to be broken down by the action of soil
microorganisms and made available to the plant hence, these manures should be applied well in advance before they are required by the trees.

**Methods of application of fertilizers**

The commercially adopted methods of application of fertilizers are 1. soil application, 2. foliar spray and 3. fertigation

**Soil application:** Soil application of fertilizers depends on pattern of distribution of active feeding roots of fruit species and time when these nutrients are required most. Inorganic fertilizers such as ammonium sulphate, urea, ammonium nitrate, sodium nitrate, urea, etc. may be applied in a round strip along the drip of the tree. A light irrigation to dissolve the fertilizer may be given. Phosphorus, when applied to the soil, gets fixed up at the spot where it is applied even if plenty of water is present in the soil, and as such, the application of phosphorus should be made near the roots so as to make it readily available to the plant. In plants having superficial roots, phosphates may be applied in top 5 to 7.5 cm layer. In case of plants having their feeding roots deep as in mango, a trench round the drip of the branches about 15 to 25 cm deep should be dug and phosphates applied in that trench and trench filled in. Potash, like nitrogen is readily soluble and is easily available to the plant and, as such, the method of application of potash is similar to that of nitrogen.
**Foliar application:** Nutrients can also be applied through foliar sprays to increase the efficacy of the applied nutrients. Foliar application of nitrogen as urea, phosphorus as calcium phosphate and potassium as potassium chloride is practiced in fruit orchards. Response of foliar application can be seen only when the status for a particular nutrient is in the deficient range. However, many plant nutrients are needed in such great quantities that it is impractical to supply them through the foliage. Fertilizer materials suitable for foliar application must be soluble in water. Most of these are salts and when applied in too high a concentration the solution will cause burning of the plant tissue. Often the safe concentration of the fertilizer material in the solution is so low that repeated applications are required to supply the needs of the plant. This is especially true of nitrogen, phosphorus, and potassium. However, to correct the deficiency of micronutrients in fruit trees foliar application is generally recommended.

<table>
<thead>
<tr>
<th>Source (formula)</th>
<th>% Nutrient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper sulphate (CuSO$_4$.5H$_2$O)</td>
<td>25-35% Cu</td>
</tr>
<tr>
<td>Zinc sulphate (ZnSO$_4$.7H$_2$O)</td>
<td>22-35% Zn</td>
</tr>
<tr>
<td>Borax or Sodium borate(Na$_2$B$_4$O$_7$.10$H_2$O)</td>
<td>10.6% B</td>
</tr>
<tr>
<td>Manganese sulphate (MnSO$_4$.4H$_2$O)</td>
<td>23% Mn</td>
</tr>
<tr>
<td>Ammonium molybdate ( (NH$_4$)$_6$Mo$<em>7$O$</em>{24}$.4$H_2$O)</td>
<td>54% Mo</td>
</tr>
<tr>
<td>Ferrous sulphate (FeSO$_4$.7H$_2$O)</td>
<td>20% Fe</td>
</tr>
</tbody>
</table>

**Fertigation:** Advances in micro-irrigation technologies such as drip and under-tree sprinkler have facilitated more wide adoption of fertigation, especially for perennial fruit crops. It is generally believed that fertigation improves nutrient uptake efficiency and preferred over broadcast application of dry fertilizers. It also increases yield and improves quality and reduced loss of nutrients.

**Students Activities**

1. Calculate the manure and fertilizer requirement of five fruit trees in your locality and prepare a list of fertilizers and FYM which can be applied to those fruit trees.
2. Make solution of micro-nutrients and spray on fruit trees grown in the locality.
3. Apply solid fertilizers to the drip line basin in few fruit tree in the locality.

**Study Material**

OBSERVING DECLINES IN THE ORCHARDS AND STUDY THEIR CAUSES

Exercise
Observing declines in the orchards and study their causes.

Objectives

- To learn about symptoms of orchard decline
- To know about causes of orchard decline
- To know about important measures to control decline in orchards

Delivery schedule: 01 periods

Student expectations/learning objectives

- To know about decline syndrome in fruit orchards.
- To know about important measures to control decline in orchards.

Handouts/material/equipment's & tools required: Practical note book, pen, and pencil to note down the important points on orchards decline, secateurs, magnifying lens, gloves, Petri plates, forceps and pruning saw.

Pre-learning required: Pre-requisite knowledge about plant health and cultivation practices of important fruit trees.

Introduction

Orchard decline is common in fruit orchards which results in loss to the productivity of orchards. You might have visited orchards of fruit crops like apple, citrus, guava, peach, pear, plum, mango, sapota etc. in your locality. In some orchards trees are having green foliage, vigorous growth with no sign of sickness. These types of fruit trees in orchards are healthy and able to produce good quantity and quality of fruits. In contrast, fruit trees in some orchards are showing sickness, chlorosis, die back, sparse foliage, gum exudation, bark splitting, twig and branch decay etc. All these symptoms are indication of decline of fruit trees and such conditions of fruit trees make them unproductive and consequently death of trees may occur.

Decline of fruit trees is a syndrome i.e., a group of symptoms that collectively indicate or characterize the abnormal condition of the plant. Causes of decline syndrome may be varying with the plant species. Edaphic factors like disturbed soil structure, soil pH, defective drainage, excessive salts, excessive free lime, low soil
organic matter, soil erosion may be responsible for decline of fruit trees. Similarly, varietal factors, rootstocks, faulty irrigation practices, indiscriminate use of fertilizers and chemicals and intensive intercropping may also be equally responsible for decline of fruit trees as well as orchards. Furthermore, incidence of insets and pest in the orchards and diseases caused by fungus, bacteria, viruses and nematodes contribute significantly to the decline conditions of trees.

**Identification of affected trees in different fruit crops**

**Citrus**

- In early stage, symptoms are restricted to a few limbs but eventually the whole plant is involved.
- Tree show sparse mottling leaves, stunted growth, sickly appearance
- Midrib and lateral veins of old, mature leaves turn yellow with internal areas along the veins, showing diffuse yellowing.
- Leaves may turn yellow and are shed with the onset of summer or autumn and the die back of twigs started.
- The entire outside of the tree bears short twigs carrying narrow small leaves on their lower portion.
- There is excessive flowering but the fruits are not carried to maturity. Either only few trees or entire orchard may be affected.

**Mango**

- Decline complex is manifested in the form of twig blight, tip die back, gummosis and bark splitting.
- As a preliminary symptom, drying of the tip, discoloration and darkening of the bark some distance from the tip becomes visible. It progresses downward involving bigger branches, as a result the leaves are shed.
- Sometimes gum exudates from the diseased portions. Bark splitting or cracking may also be noticed in severe cases.
Dieback, twig blight, defoliation, gummosis, vascular discoloration, marginal chlorosis, necrosis of leaves, nutritional deficiencies and root degeneration. These symptoms are found alone or in combination with each other in different mango orchards.

In addition to decline complex, a new disease named as quick decline or collar rot has become the most destructive hazard in mango orchards.

Factors responsible for decline

Citrus

The citrus decline is a syndrome of various symptoms and caused by number of biotic and abiotic factors. Unfavourable soil condition, the presence of impregnated layers of the CaCO₃, bad drainage cause poor aeration, salt concentration exceeds 1000 ppm, leaching of nutrients due to low pH and heavy rainfall, lack of adequate plant nutrition, incompatibility between stock and scion, excessive intercropping, inadequate tree spacing, inadequate manuring and attack of pests (leaf minor, citrus trunk borer, twig borer), diseases, citrus Tristeza virus, citrus nemetode and nutrition disorder are responsible for citrus decline. Furthermore, negligence in management of orchards is prime cause of decline.

Mango

Mango decline syndromes are recognized in virtually all mango-production regions. Although fungi are the implicated incidents at many locations, abiotic stresses, nutritional deficiencies, are thought to play roles in other situations. On combination of these symptoms with root degeneration caused by soil borne pathogens, plants are ultimately destined to complete drying. Plant once predisposed to preliminary decline symptoms due to weak vigour and presence of inoculum becomes prone to even weak or secondary colonizers.

Management of orchard decline

Good cultural practices, improvement of soil fertility, drainage, control of diseases, pests and nematodes may be useful to minimize the incidence of this melody. The grower should adopt suitable orchard management practices and this would lead to the control of citrus and mango decline problem to a great extent. Tips for management of orchard decline in citrus orchard are as follows:

Citrus decline

- Make half moon terraces/tree basin for placement of manure and fertilizers to reduce nutrient loss.

- Water sprouts, rootstock scion, diseased and dried/dead branches/twigs should be removed and cut end should be pasted with bordeaux paste.

- Keep the basin free from weeds and mulch with dry grass during dry month.

- Manure and fertilizer should be applied as per recommended doses @ 50-60 kg well rotten FYM, 2000 g urea, 3000 g SSP and 1500 g muriate of potash/tree/year in three equal split doses. The 1ˢᵗ split dose of fertilizer should be applied in the month of March-April and subsequent doses in June-July and September-October.
- Slaked lime @4-5 kg/tree should be applied in February in alternate year.

- Spraying should be given with zinc sulphate (0.5%) + magnesium sulphate (0.2%) + copper sulphate (0.4%) + magnese sulphate (0.4%) during flushing period.

- Flower and fruits should be reduced by hand thinning or chemical spraying.

- Pasting of tree trunk up to 60 cm ground level with Bordeaux paste in March-April and August-September.

- Collection and destruction of trunk borer adults by shaking the branches in May.

- Pasting of trunk up to 1.5 m height with 1% carbaryl along with sticker during II\textsuperscript{nd} week of May to check adults of trunk borer from oviposition on the trunk.

- Control of trunk borer grubs by injecting petrol insedicide soaked cotton inserted in hole and plug it with wet mud in August-September.

- Spraying of bavistin (1g/l) + monocrotophos (1ml/l) on new flushes in March-April and July-August for controlling the insect-pest and disease.

- Spray malathion (2 ml/l) in September - October. over fruit to prevent fruit fly egg laying.

- Spray 1% bordeaux mixture or 0.3% blitox-50 during March-September to control dieback, scab and sooty mould diseases.

**Students Activities**

1. Visit fruit orchards in your locality and try to identify the fruit trees showing sign of decline.
2. Visit fruit orchards and try to find out decline symptom(s) on different fruit tree in an orchard.
3. Enquire from the orchardist about remedial measures taken for control of decline in orchard.

**Study Material**


Exercise

Studying morphological characteristics of available varieties in fruit crops.

Objectives

- To Study the morphological characteristics of available varieties in fruit crops

Delivery schedule: 02 period

Student expectations/learning objectives

- To know the different types of varieties available in fruit crops.
- To get familiar with different types of varieties on the basis of their morphological characters.

Handouts/material/equipment's & tools required: Paper sheet and pen to note down the morphological characters of different varieties.

Pre-learning required: Pre-requisite knowledge of some of the commonly grown varieties in the locality.

Introduction

Morphological characterization is one of the methods accepted for registration and protection of new cultivars in each crop. The cultivar identification is traditionally based on the observation of morphological characteristics whose expression is largely influenced by developmental, environmental and cultivation factors. Furthermore, it is necessary to find morphological descriptors that are able to distinguish among different cultivars. The morphological characters will be able to distinguish between the varieties of each crop. Before knowing detail descriptors for fruit crop, we would like to get familiar with some of the terms related to this practical exercise.

Useful terms

Descriptor: Within the plant genetic resources community, a descriptor is defined as an attribute, characteristic or measurable trait that is observed in an accession of a genebank. It is used to facilitate data classification, storage, retrieval, exchange and use. Example: accession number, flower colour, plant height etc.

Descriptor list: It is a set of individual descriptors used for the description of germplasm of a particular crop or species.

Descriptor elements: Each descriptor consists of a descriptor name, a descriptor state, and a descriptor method explaining how the descriptor should be measured and recorded. A descriptor state could be a quality, measurable attribute or code.
Example:

- Stem pubescence (descriptor name)
- Observed at the stem base (descriptor method)
- 3 Sparse (descriptor state)
- 5 Intermediate (descriptor state)
- 7 Dense (descriptor state)

In above Example, 'stem pubescence' is the descriptor name, 'observed at the stem base' is the descriptor method, and 'sparse; intermediate; dense' are the descriptor states, with corresponding numbering codes (3, 5, 7) assigned to descriptor states for ease of documentation.

Descriptor names: The descriptor should have a full name that is descriptive, unambiguous and as compact as possible. Descriptor names are frequently composed of an object or item, and a characteristic or attribute name. When choosing a descriptor name, it is essential to verify that the technical terms are correct and that they are generally accepted and understood by other users.

Example:

- Accession number
- Species name
- Leaf colour
- Flowering habit
- Soil fertility

Descriptor states: For a number of qualitative and quantitative descriptors, a descriptor state is a clearly definable state of expression to define a characteristic and harmonize descriptions. It represents the variation in the observations or measurements made on a particular descriptor. Each descriptor is allocated a corresponding numeric code for ease of data recording and exchange. Reference materials can be used to help define the various states of expression of traits, and recommended resources include drawings, check cultivars, colour charts, phenological scales, illustrations, and lists of possible values or codes (if applicable). Examples of such reference material are given in the following sections.

Example:

Leaf shape

1 Obovate (descriptor state)
2 Elliptic (descriptor state)
3 Oblong (descriptor state)
4 Ovate (descriptor state)

Drawings: Since collections of the plant genetic resources of a crop could be sited anywhere, and large in number, a collection may not have access to a standard reference, so simple line drawing or pictures of stem
branching, for example, are easier to refer to and will help users to selecting states of expression of a trait, avoiding confusion with environmental effects. Figure captions should be brief, but complete, and should contain the name of the relevant descriptor. If a figure is taken from or based on another source, a full bibliographic reference to the source should be included in an appendix of the descriptor list.

Example:

**Stem branching**

1. Opposite
2. Alternate
3. Ternate
4. Mixed

**Reference standards and parameters**

When a descriptor state is open to interpretation or difficult to explain, reference standards or specific parameters can be used to clarify it. Reference standards provide an objective baseline against which measurements and comparisons can be made. They provide the means to make observations more consistent and comparable. Often, a common cultivar is used as a standard and the standard reference is then used as a check. Check cultivars and standard references also provide useful corollary information to gauge the performance of the accessions being tested. Check cultivars should be widely available and known.

Example:

**Blade shape of mature leaf**

- Rounded leaf
- Reniform
- Cordate

**Colour charts**

A fruit colour descriptor that describes different shades of a colour would benefit greatly from the use of a colour chart or reference standard, if available. Without a reference for comparison, descriptor states such as 'light green', 'green' and 'dark green' cannot be scored consistently and objectively.

**Fruit colour RHS colour code (RHS, 1986)**

1. Light green 145A
2. Green 146A
3. Dark green 147A

**Parameters**

It is strongly recommended to use actual measurements (cm, g, mm) for making good use of quantitative data (i.e. continuous variation) for genetic diversity analysis. Actual measured values can also give us statistical data to assess variation within an accession. Character states as listed below should be used only when measuring is very difficult. For instance, a fruit length descriptor should specify relevant ranges of
measurements to avoid misinterpretation by different users. Without these ranges, descriptor states cannot be scored consistently or objectively.

**Example:**

<table>
<thead>
<tr>
<th>(WRONG)</th>
<th>(RIGHT)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fruit length</strong></td>
<td><strong>Fruit length</strong></td>
</tr>
<tr>
<td>1 Very short</td>
<td>1 Very short (&lt;2 cm)</td>
</tr>
<tr>
<td>2 Very short to short</td>
<td>2 Very short to short (&gt;2 – 4 cm)</td>
</tr>
<tr>
<td>3 Short</td>
<td>3 Short (&gt;4 – 6 cm)</td>
</tr>
<tr>
<td>4 Short to intermediate</td>
<td>4 Short to intermediate (&gt;6 – 8 cm)</td>
</tr>
<tr>
<td>5 Intermediate</td>
<td>5 Intermediate (&gt;8 – 10 cm)</td>
</tr>
<tr>
<td>6 Intermediate to long</td>
<td>6 Intermediate to long (&gt;10 – 12 cm)</td>
</tr>
<tr>
<td>7 Long</td>
<td>7 Long (&gt;12 – 14 cm)</td>
</tr>
<tr>
<td>8 Long to very long</td>
<td>8 Long to very long (&gt;14 – 16 cm)</td>
</tr>
<tr>
<td>9 Very long</td>
<td>9 Very long (&gt;16 cm)</td>
</tr>
</tbody>
</table>

**Descriptor methods**

A descriptor method describes in detail how and under what conditions a descriptor is measured or scored. The description method facilitates accurate interpretation of results and provides a protocol to be universally and consistently applied.

**Example:**

*Plant height (cm)*

Recorded at maturity, measured from ground level to a feet height (or) one meter. Average of 3.5 randomly selected plants. It is important to use technically correct terminology in descriptions. If possible, record any bibliographical references consulted and list them in an appendix to the descriptor list. This will allow others to verify the terminology and methodology.

**Descriptor method elements comprise:**

- an **Object**
- a **Condition**
- a **Sampling procedure**

**Object:** This defines the exact part (s) of the plant to be observed or measured. A measurement of plant height that does not specify exactly between which points the measurement should be taken is incorrect, because different people may use different measuring points. In the case of quantitative descriptors, a unit of measurement should be defined. It is recommended to use only the system International d'Unités (SI) and to include the units to be applied in square brackets following the descriptor name.
**Condition:** This defines the conditions under which the observation is made, such as duration, plant growth stage, phenological condition, temperature, humidity, 'priming' (pre-observation treatments), and specifications of particular equipment if required. In the above example 'fully developed' is the condition.

**Sampling:** The number of samples on which the observation is based should be given, thus providing an indication of data accuracy within the method. The type of method used for sample selection (random, stratified, etc.) should also be indicated. When variation of a characteristic within the accession is prevalent, it is essential to describe how the samples are to be selected and how many samples are needed.

Familiarized with above terms and procedure now it will be easy to describe the varieties morphologically, considering all above points.

### Morphological description of mango varieties

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Characters</th>
<th>Varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(Alphonso)</td>
</tr>
<tr>
<td><strong>Leaf characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Leaf shape</td>
<td>Lanceolate</td>
</tr>
<tr>
<td>2.</td>
<td>Leaf length (cm)</td>
<td>32</td>
</tr>
<tr>
<td>3.</td>
<td>Leaf width (cm)</td>
<td>7</td>
</tr>
<tr>
<td>4.</td>
<td>Petiole length (cm)</td>
<td>6.5</td>
</tr>
<tr>
<td>5.</td>
<td>Colour of fully developed leaf</td>
<td>Medium green</td>
</tr>
<tr>
<td>6.</td>
<td>Leaf tip</td>
<td>Acuminate</td>
</tr>
<tr>
<td>7.</td>
<td>Leaf margin</td>
<td>Twisted</td>
</tr>
<tr>
<td><strong>Fruit characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Fruit length (cm)</td>
<td>10.5</td>
</tr>
<tr>
<td>2.</td>
<td>Fruit thickness (cm)</td>
<td>8.4</td>
</tr>
<tr>
<td>3.</td>
<td>Fruit weight (g)</td>
<td>293</td>
</tr>
<tr>
<td>4.</td>
<td>Fruit shape</td>
<td>Obovoid</td>
</tr>
<tr>
<td>5.</td>
<td>Colour of ripen fruit</td>
<td>Yellow</td>
</tr>
</tbody>
</table>

### Secondary characteristics

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Characters</th>
<th>Varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Excellent</td>
</tr>
<tr>
<td>2.</td>
<td>Fruit attractiveness</td>
<td>Excellent</td>
</tr>
<tr>
<td>3.</td>
<td>Basal cavity</td>
<td>Shallow</td>
</tr>
<tr>
<td>4.</td>
<td>Beak type</td>
<td>Perceptible</td>
</tr>
<tr>
<td>5.</td>
<td>Sinus type</td>
<td>Absent</td>
</tr>
<tr>
<td>6.</td>
<td>Slope of shoulders</td>
<td>Rising and then rounded</td>
</tr>
<tr>
<td>7.</td>
<td>Apex</td>
<td>Abtuse</td>
</tr>
<tr>
<td>8.</td>
<td>Fruit stalk attachment</td>
<td>Strong</td>
</tr>
</tbody>
</table>
From the above table we can see the difference in their morphological characters between the three varieties. Likewise variety may vary in its morphological characteristic i.e, the characters are variety specific.

**Students Activities**

- The students can use the above descriptors and try with different varieties of guava, papaya, apple or any available fruit crops in a particular locality.

- The descriptors may vary according to the crop, based upon morphology

- Student can make a visit to nearby locality and practice to score different fruit crops in their locality

**Study Material**


- Morphological Description of Mango Varieties under Agro-climatic Conditions of Gujarat, 2013 Pub. AICRP(STF), CISH, Lucknow, India.
Exercise
Identification of important diseases of fruit crops.

Objectives

- To identify important diseases of fruit crops

**Delivery schedule:** 01 period

**Student expectations / learning objectives**

- To know the important diseases of fruit crops
- To identify the diseases affected in major fruit crops
- To learn how these diseases may cause losses to the fruit crops.

**Handouts / material / equipment's & tools required:** Paper sheet and pen to note down the different diseases and to collect few specimens from field and to note down some of the important features of the particular diseases.

**Pre-learning required:** Pre-requisite knowledge of diseases that affect fruit crops and their symptoms.

**Introduction**

The term 'DISEASE' is coined by combining the words DIS + EASE = DISEASE. The prefix DIS means negative, reverse, or opposite, and the word EASE means comfort, or freedom from pain or discomfort. DISEASE therefore means not well, and the cause can be many. Disease can be defined as a harmful deviation from normal functioning of the physiological processes caused by an infectious agent. However, a harmful deviation caused by a non-infectious agent, For example, herbicide or nutrient deficiency, is a disorder. In the case of plant diseases, the causal agent may be a fungus, virus, bacterium or a parasitic plant. The study of plant diseases are important as they cause loss to the produce. Hence, the diseases are required to be prevented and controlled to avoid loss of valuable food.

The diseases can be classified into following three types on the basis their occurrence and severity.

1) **Endemic diseases:** Endemic means prevalent in and confined to a particular locality. These diseases are more or less constantly present in a particular area. Examples, Moko diseases of Banana

2) **Epidemic diseases:** These diseases occur incidentally and occasionally in a particular locality. The word epiphytotic is used particularly for plant diseases instead of epidemic. Examples, European stone fruits yellow in stone fruit species

3) **Sporadic diseases:** These occur at very irregular intervals and locations. Examples, Dry root rot of citrus
Classification of plant diseases on the basis of modes of their spreading:

1) **Soil borne diseases:** Inoculums of the diseases causing pathogen remains in soil and penetrate the plant resulting in diseased condition. Examples, Guava wilt and pomegranate wilt.

2) **Seed borne diseases:** The microorganisms are carried along with seeds and cause diseases when congenial condition occurs. Examples, Cherry yellows in stone fruits

3) **Air borne diseases:** The micro-organisms are spread through air and attack the plants causing diseases. Examples, blight in mango, rust in aonla, powdery mildew in ber

4) **Diseases spread by insects:** The viral diseases are spread by insects. The insects which carry the viruses are known as vectors. Examples, Citrus tristeza decline, papaya leaf curl, papaya ring spot, Citrus greening

In order to have management of these diseases, student should have the idea of the casual organism, crops affected and disease symptoms.

**Major diseases of fruit crops**

<table>
<thead>
<tr>
<th>Fungal diseases - Leaves and inflorescence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>Powdery mildew</td>
</tr>
</tbody>
</table>

For teachers...

- Make students to understand the different types of diseases.
- Practically, show the students, different types of disease symptoms in each crop.
- Ask the students to collect some commonly available disease samples from the field.
Brown rot

The blossom blight phase kills flowers at bloom; the fruit rot phase occurs within days of harvest. Brown, soft spots spread rapidly, producing powdery tan spores.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Pathogen</th>
<th>Crops</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown rot</td>
<td>Monilinia sp.</td>
<td>Peach, apricot, plum, cherries, almond, quince</td>
<td>The blossom blight phase kills flowers at bloom; the fruit rot phase occurs within days of harvest. Brown, soft spots spread rapidly, producing powdery tan spores.</td>
</tr>
</tbody>
</table>

### Anthracnose

Small to large, brown or black, sunken lesions on fruit surface near harvest; lesions may coalesce in badly infected fruit. Lesions usually dry and firm.

<table>
<thead>
<tr>
<th>Anthracnose</th>
<th>Colletotrichum sp.</th>
<th>Avocado, banana, guava, mango, papaya,</th>
<th>Anthracnose in banana</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Anthracnose in mango</td>
</tr>
<tr>
<td>Fungal diseases- Trunk, crown and roots</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Disease</strong></td>
<td><strong>Pathagen</strong></td>
<td><strong>Crops</strong></td>
<td><strong>Symptoms</strong></td>
</tr>
<tr>
<td>Root / crown rot</td>
<td><em>Phytophthora</em></td>
<td>Apple, citrus, papaya, pear, peach, apricot, cherry, plum, citrus</td>
<td>Poor shoot growth, chlorotic leaves and generally lack of vigor. Shoot dieback and tree collapse may occur after rainy periods.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bacterial diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Disease</strong></td>
</tr>
<tr>
<td>Bacterial canker</td>
</tr>
<tr>
<td>Fire blight</td>
</tr>
<tr>
<td>Citrus canker</td>
</tr>
</tbody>
</table>
### Viral diseases

<table>
<thead>
<tr>
<th>Disease</th>
<th>Pathagen</th>
<th>Crops</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bunchy top</td>
<td>Banana bunchy top virus</td>
<td>Banana</td>
<td>Plants are extremely stunted, Leaves are reduced in size marginal chlorosis and curling. Leaves upright and become brittle. Many leaves are crowded at the top.</td>
</tr>
<tr>
<td>Papaya ring spot</td>
<td>Papaya ring spot virus</td>
<td>Papaya</td>
<td>Circular concentric rings are produced on the fruits. Margin and distal parts of leaves roll downward and inwards, mosaic mottling, dark green blisters, leaf distortion which result in shoe string system and stunting of plants.</td>
</tr>
<tr>
<td>Leaf curl</td>
<td>Papaya leaf curl virus</td>
<td>Papaya</td>
<td>Curling, crinkling and distortion of leaves, reduction of leaf lamina, rolling of leaf margins inward and downward, thickening of veins.</td>
</tr>
</tbody>
</table>

**Students Activities**

1. Visit to nearby orchards and try to collect samples of diseased plant and examine.
2. You can also note down the diseases in each crop around your locality.

**Study Material**

IDENTIFICATION OF IMPORTANT INSECTS AND OTHER PESTS OF FRUIT CROPS

Exercise
Identification of important insects and other pests of fruit crops.

Objectives
- To identify important insects and other pests of fruit crops

Delivery schedule: 01 period

Student expectations / learning objectives
- To know the important pest of fruit crops
- To identify the pest of fruit crops
- To learn how these pests could cause damage to the fruit crops.

Handouts / material / equipment's & tools required: Paper sheet and pen to note down description of different insect pests, insect collecting net, insect collection bottles, insect specimens.

Pre-learning required: Pre-requisite knowledge of insects pests of fruit crops.

Introduction
Insects are found in all types of environment and they occupy little more than two thirds of the known species of animals in the world. Many of them fed on all kinds of plants including crop plants, forest trees, medicinal plants and weeds. They also infest the food and other stored products in godowns, bins, storage structures and packages causing huge amount of loss to the stored food and also deterioration of food quality. Insects causes injury to plants and stored products either directly or indirectly in their attempts to secure food. Insects damages can be grouped into three classes, they are (i) insect that cause less damage i.e, less than 5 % are not considered as pests. (ii) The insects which cause damage between 5 - 10% are called minor pests and (iii) those insects that cause damage above 10% are considered as major pests. Insects that cause injury to plants and stored products are grouped into two major groups namely chewing insects and sucking insects. The former group chews off plant parts and swallow them thereby causing damage to the crops for examples caterpillar. Sucking insects pierce through the epidermis and suck the sap for examples, fruit sucking moth etc. Many of the sucking insects serve as vectors of plant diseases for examples white fly which transmit yellow mosaic viruses in papaya and also inject their salivary secretions containing toxins that cause severe damage to the crop.

Points to be remembered
- All the insects are not causing damage to the plants, those insects are called beneficial insects like honey bee.
Do you know that some insects are also being reared for commercial productions of silk? i.e., silk worm from the pupa stage called cocoon.

Some insects feed over the other damage causing insects which are also called beneficial insects or predators.

The insect pests attack the fruit crop at various parts of the plants like roots, leaves, stem, flower, fruit and seed. But all insect does not attack all the parts.

The insect pest attack the crops at different stages of their life cycle for examples the stages of Butter fly are egg, larva, pupa, and adult. Some insects cause damage when they are in larval stage, some infest the crops in adult stage.

Some insects are poisonous to human being also, care should be taken while handling such insects, like wasps, bugs etc.

Before considering the insect pest damage, one should have an idea about the types of insects in the orchards, their stage of damage to the crops.

**List of important insects and pests of fruit crops**

**Fruit sucking moth (Otheris materna)**

The larva of *O. fullonica* is orange blue in colour and having yellow spots on velvety dark speckled on the body. The adult is a stout moth, which has orange coloured wing. Whereas in case of the other species like *Otheris materna* there will be three black spots on the fore wing and in *O. ancilla* the adult will have a white colour band in the middle fore wing. The adult will pierce the fruit and suck the juice resulting in rottening at the feeding site.

**Citrus or lemon butterfly (Papilio demoleus)**

The early stage larva of this insects will resembles or looks like a bird dropping and when it is grown up (larva) will be cylindrical, stout, green and brown lateral band near the fore head. The adult is dark brown in colour with yellow to creamy white numerous irregular spots on the wings. The main thing to be remembered is that the larva are called as caterpillars which is the most destructive stage and its prefers on light green tender leaves, having the quality of feeding voraciously and leaving only the mid-ribs, severe infestation the entire tree gets defoliated.

**Tea mosquito bug (Helopeltis antonii)**

The adult bug is reddish-brown, about 6-8 mm long with a black head, red thorax, black and white abdomen. Female bug lays eggs on the tender tissues of new shoots, and soft tissues of inflorescence branches. Both nymphs and adults of this bug suck sap from the tender flushes, young shoots, inflorescence, panicles, growing young nuts and cashew apples. Occurrence of dark brown patches on green tender stem of young shoots and inflorescence rachis. Feeding on tender leaves causes crinkling and curling and affected shoots show long black lesions.
**Fruit fly (Bactrocera dorsalis)**

The adult flies are light brown in colour with transparent wings. Adult flies are very conspicuous. These are about 7 mm long, with hyaline wings, thorax ferrugineous without yellow middle stripe, legs yellow, abdomen conical in shape and dark brown in colour. The adult will lay the egg in the tender stage of the fruit like mango, guava etc., as the fruit matured the egg will hatch out and will feed the fruit from inside.

**Stem borer (Batocera rufomaculata)**

The adult is grayish in colour. The beetle also has two pink dots and a lateral spine. The grub is the most destructive stage which tunnels in the sapwood on the trunk or branches, bore into the sap wood and making irregular tunnels and feeding the vascular tissues. This causes drying of terminal shoot in early stage and fress comes out from several points and sometimes sap oozes out of the holes, finally causes wilting of branches or entire tree.

**Mealy bugs (Drosicha mangiferae)**

The adult male mealy bug has a wing, long antenna and without mouth parts. The female adult is wingless, with a flat body and short, waxy filaments along the margins. The mealy bugs causes damage through sucking of saps there by leads to drying of the shoots and inflorescence.

**Banana rhizome weevil (Cosmopolites sordidus)**

The adult is a dark brown colour weevil and a newly emerged weevil looks red brown in colour. The grubs (young ones) bore into the rhizome and cause death of the plant. It symptoms can be identified by the presence of dark coloured tunnels in the rhizomes. It causes the death of unopened pipe and withering of outer leaves.

**Banana aphid (Pentalonia nigronervosa)**

The younger ones are called Nymphs and they are dark in colour. The adult is brownish in colour and has black veined wings. It is a sap feeder and transmits bunchy top of banana virus.

**White flies (Bemisia tabaci)**

The adult is white in colour and tiny in size and look like a scale-like adults. Nymphs and adults suck the sap from under surface of the around the leaves veins, which causes yellowing of leaves. Plants will become extremely weak and may be unable to carry out photosynthesis. Leaves may dry out and growth will be stunted.

**Citrus leaf miner (Phyllocnistic citrella)**
The eggs are minute, flattened in shape and present on the lower side of the midrib of leaves. The larvae are minute, yellowish or reddish in colour and apodous in nature. Settled down on the edge of the folded leaves. The adult is a minute moth with a black spot at the tip of the fore wing. The caterpillars (larva) will attack the tender leaves and feed on the epidermis which will be looking like silvery appearance on the lower surface of leaves. It also get leaves distorted crinkled in severe attack plant causes the leaf defoliation

**Students Activities**

1. Try to collect some of the insects and identify them
2. Make a list insect's pest that causes damage to the fruit crops available in your locality
3. Make attempt to train yourself to differentiate different type of insects pest

**Study Material**


Exercise
Preparation of pesticide solutions and their safe spraying in orchard.

Objectives

- To know how to prepare pesticide solutions and their safe spraying in orchard

Delivery schedule: 01 period

Student expectations / learning objectives

- To know about different types of pesticides
- To learn about preparation of pesticide solutions
- To learn about safe application of pesticides in fruit orchards

Handouts / materia l/ equipment's & tools required: Paper sheet and pen to note down the different types of pesticides and to note few specimens from farm / pesticide shops. Important instructions can also be noted on a sheet.

Pre-learning required: Pre-requisite knowledge of some of the pesticide commonly used in fruit crops and their Do's and Don't

Introduction

A pesticide is a substance or a mixture of substances intended for preventing, destroying, repelling, or lessening the damage of any pest / insects. Fruit growers adopt different ways to control insects and pests in their fruit orchards. Traditional eco friendly pesticides like plant extracts such as neem seed extracts, neem leaf extracts, chrysanthemums, rotenone derivates or common chemicals such as sulfur in the form of sulphur dust etc. and animal derivatives like cows urine etc. Similarly, various chemical pesticides are available and extensively used by the fruit growers in current time. These chemical pesticides are poisonous to human being. The indiscriminate use of these chemical pesticides may cause hazard to humans and can also pollute soil and water. Since most of the pesticides are poisonous and causes health hazards to human being, we should know the safe method of use of these pesticides. For example, how to prepare pesticide solutions, how to mixing it with different chemicals and what precautions one should take during spray of these pesticides?

Students should know

- Different types of pesticides available in the market
- Knowledge about active ingredients in different formulations
- How to prepare pesticide solutions?

For teachers…

- Demonstrate the safe application of insecticides to the students.
- Show different type of insecticides available in local
How to mix pesticides with other chemicals?

Precautions during preparation and spray of pesticides in fruit orchards.

**Contact pesticides:** Based on the mode of action some pesticides are categorized as contact pesticides. In order to have maximum efficiency these chemicals are need to be absorbed through the external body surface of the insects or the exposed plant tissues, where the pests cause damage. Contact pesticides when applied should reach their target directly to have effective control.

**Systemic pesticide:** This category of pesticides are absorbed by the plant or insects and moved (translocated) from the site of application to another site within the plant or insects where they become more effective. When insects feed on plants tissues, they are killed by systemic insecticide already present the plant tissues.

**Insecticide formulations:** Different types of pesticide are available in different formulations like, wettable or soluble powders, liquid concentrates or emulsion concentrates (EC). These chemicals must be diluted, usually with water, before use. Other diluents, such as deodorized kerosene, may be used for special applications.

**Spray volume and active ingredient:** While preparing the pesticide solution some should take into consideration the quantity of spray volume required for spraying a specific area. Students may also like to know that in some cases the spray volume is also calculated based upon the number of tree planted in an unit area and the volume required to cover each tree canopy. Dusts and granules are applied without dilution by the farmers. Therefore, in this case the recommended dose to be applied based on the recommendation by the scientist to specific crop. The amount of active ingredient in liquid concentrates is expressed in percent EC for examples” in chlorpyrifos 20% EC. In case of granules, dusts, wettable or soluble powders it is expressed as percent by weight (Fipronil 0.3% GR, Ridomil Gold i.e., Metalaxyl M 4.0% and Mancozeb 64.0% WP). Application rates are usually expressed as ml / litre or mg / litre in case of powder.

**How to prepare insecticide solution for spray**

1. **Quantity of insecticide required**

   The required of quantity of commercial formulation of the insecticide can be calculated by the formulae.

   \[
   \text{Volume of spray liquid} \times \text{Strength of the spray solution desired (\%)} = \text{Quantity of finished spray solution required}
   \]

2. **Strength of the finished spray solution**

   To calculate the strength of a finished spray solution when a known quantity of chemical is added to known quantity of water, the following formulae may be adopted.

   \[
   \text{Quantity of the insecticide used} \times \text{Strength of the insecticide (\%)} = \text{Quantity of finished spray solution required}
   \]

3. **In case of granules**

   \[
   \text{Quantity of chemical needed} = \frac{\text{Recommended dose } a.i. \text{ / ha } \times 100}{\% \text{ a.i. of insecticide}} \times \text{Area}
   \]
Key points to be remembered

While purchasing

- Purchase a pesticides / biopesticides only from a registered pesticide dealers having valid licence.
- Purchase only required quantity of pesticides for current use.
- Check approved labels on the containers / packets of pesticides.
- Check Batch No., Registration Number, Date of Manufacture / Expiry on packet.
- Purchase the pesticides which are in packed containers.

Storage of pesticide

- Store the pesticides away from house premises.
- Keep pesticides in original containers.
- Pesticides / weedicides must be stored separately.
- Pesticides be stored away from the reach of the children and livestocks.
- Keep pesticides in a separate container during transportation.
- Bulk pesticides should be carried tactfully to the site of application.

Preparation of insecticide solution

- Always use clean water or fresh water for mixing of chemicals or pesticides.
- Always use protective clothing when handling pesticides viz., handgloves, face masks, cap, apron, full trouser, etc. to cover whole body.
- Take care to protect your nose, eyes, ears, hands, etc. from spill of spray solution.
- Read the instructions on pesticide container label carefully before use.
- Avoid spilling of pesticides solutions while filling the spray tank.
- Always use recommended dosage of pesticide.
- Do not eat or drink during handling of pesticides.
Selection of equipment

- Select right kind of equipment. Select right sized nozzles. Use separate sprayer for insecticides and weedicides.

Spraying of insecticide

- Apply only recommended dose and dilution.
- Spray operation should be conducted on cool and calm day.
- Spray operation should be conducted on sunny day in general.
- After every spray operations, sprayer, buckets should be washed with clean water using detergent / soap.
- Avoid the entry of workers/domestic animals in the field immediately after spray.

After spray operation

- Left over solutions should be disposed off at safer place.
- The used / empty containers should be crushed and buried deep in soil.
- Wash hands and face with clean water and soap before eating.
- On observing poisoning symptoms give the first aid immediately and take the patient to a doctor. Also show the empty container to doctor.

Students Activities

- Visit to nearby orchards and try to note down different pesticide and their formulations used. Make a list of pesticides available in the local market with their active ingredient.

- An orchard of mango (100 plants) has severe infestation of mango hopper. Mango expert has suggested spray of 0.06% dimethoate to control the insect. Calculate the amount of Rogar insecticide (35% EC dimethoate) required for spray assuming that 10 litre solution per plant is sufficient.

- Practice preparation and spray of insecticide in fruit orchard with all precautions.

Study Material


EVALUATING THE TASTE OF FRUIT CULTIVARS

Exercise
Evaluation of the taste of different fruits and their varieties

Objectives

- To visit a local market to identify different fruits
- Taste evaluation of different fruits and their varieties

Delivery Schedule: 02 periods

Students expectations/ learning objectives:

- Identification of different fruits, which are being sold in the market
- Procedure of taste evaluation of fruits.

Handout and material required: paper sheet, pen to note down the instructions, evaluation sheet, spoon, kitchen knife, plates and fruit samples.

Pre-learning required: Preliminary knowledge about different fruits.

Introduction
Taste evaluation practical is aimed to introduce students to basic taste of different fruits and their varieties. Four basic tastes such as sweet, sour, salty and bitter have been recognized. The tongue is the seat of the taste evaluation. The taste buds are on the tongue located on different places and are specific for various tastes. The sense of taste is highly useful in recognition, selection and acceptance of fruits. Depending on the concentration of the foods to be tasted, four fundamental taste qualities give variable sensation of pleasantness and unpleasantness. It has been proved that pleasantness of sucrose tasting increases as its concentration is increased. However, taste of food containing sodium chloride (common salt) increase in pleasantness only over a small range of increase in concentration, and then it gives and unpleasant sensation. In schools, taste testing can take place in the classroom or in the cafeteria.

Tips for conducting a successful taste evaluation

- Develop goals for the taste evaluation event and make students aware of the same.
- Give students the opportunity to try a variety of fruits and their different varieties.

For teachers…

- Arrange visit of students to local fruit market and show them different types of fruit available in different seasons.
- Bring fruit samples having different basic tastes and ask students to evaluate and fill the evaluation performa.
- Ensure the fruit sample looks appealing and that there is enough for everyone to try.
- Provide a fun and inviting atmosphere. Reiterate the importance of making good fruit choices to students.
- Get students feedback and ask them to fill the evaluation performa.

**Tastes of fruits**

Like several other foods, fruits also contain two or sometimes three or probably all tastes. However, sweet and sour taste is the most dominant ones. For example, unripe fruits of mango, grapes, mandarins, oranges, loquat, etc. are sour in taste but when ripe, they taste sweet, yet wider variability exist among varieties. For example, some varieties of mango are very sweet (e.g., Amrapali), and some have very good blend of sugars and acids (e.g., Alphonso, Mallika). Some fruits are difficult to taste when unripe (e.g., persimmon) as they show some level of astringency but can be eaten very pleasantly when ripe. Some fruits (e.g., aonla) initially give sour (unpleasant) but later give pleasant taste, nearly sweet. Some citrus fruits (e.g., lemon and limes) taste sour whereas some (e.g., mandarins, sweet oranges, grapefruits and pummel) usually taste sweet on maturity. When such fruits are eaten unripe they taste bitter.
### Fruits and their taste

<table>
<thead>
<tr>
<th>Fruit</th>
<th>Basic taste</th>
<th>Fruit</th>
<th>Basic taste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mango</td>
<td>Sweet</td>
<td>Mandarin</td>
<td>Sweet</td>
</tr>
<tr>
<td>Grapes</td>
<td>Sweet</td>
<td>Sweet Orange</td>
<td>Sweet</td>
</tr>
<tr>
<td>Litchi</td>
<td>Very sweet</td>
<td>Pomegranate</td>
<td>Sweet</td>
</tr>
<tr>
<td>Kiwifruit</td>
<td>Sweet-sour</td>
<td>Lemon</td>
<td>Sour</td>
</tr>
<tr>
<td>Lime</td>
<td>Sour</td>
<td>Apple</td>
<td>Mildly sweet</td>
</tr>
<tr>
<td>Pear</td>
<td>Sweet</td>
<td>Plum</td>
<td>Sweet-sour</td>
</tr>
<tr>
<td>Peach</td>
<td>Mildly sweet</td>
<td>Apricot</td>
<td>Sweet</td>
</tr>
<tr>
<td>Phalsa</td>
<td>Mild sweet-sour</td>
<td>Jamun</td>
<td>Sweet-sour</td>
</tr>
</tbody>
</table>

**Fruits which exhibit mild sweet taste**

- Guava slices
- Banana slices

**Fruits which exhibit sweet taste**

- Mango fruits
- Sapota fruits
- Litchi fruits
- Pomegranate fruits
**Varietal differences in taste**

Some varieties of a particular fruit are sweet and other are less sweet, and hence some varieties are more preferred by a selective class of people who like sweeter fruits. Thus taste of a particular variety helps in selection of rejection of variety by a particular consumer. However, in general, there is no much difference in the taste of different varieties except in sweetness.

**Fruits which usually exhibit sweet-sour taste**

- Strawberry
- Oranges
- Phalsa
- Loquat
- Peach
- Kiwifruit
- Plum
- Jamun

**Very sweet dehydrated fruits**

- Dried apricot
- Raisin (Grapes)

**Dried fruits having neither sweet nor sour taste**
Fruit Taste Evaluation Sheet

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3 4 5 6 7 8 9</td>
</tr>
<tr>
<td>Appearance</td>
<td></td>
</tr>
<tr>
<td>Peel colour</td>
<td></td>
</tr>
<tr>
<td>Pulp colour</td>
<td></td>
</tr>
<tr>
<td>Firmness</td>
<td></td>
</tr>
<tr>
<td>Sweetness</td>
<td></td>
</tr>
<tr>
<td>Sourness</td>
<td></td>
</tr>
<tr>
<td>Bitterness</td>
<td></td>
</tr>
<tr>
<td>Astringency</td>
<td></td>
</tr>
<tr>
<td>Grittiness</td>
<td></td>
</tr>
<tr>
<td>Seediness</td>
<td></td>
</tr>
</tbody>
</table>

Scale 1-9, 1 denotes absent or least preferred, 9 denotes present or most preferred

Students Activities

1. Go to some fruit exhibition and identify different fruits and their varieties.
2. Participate in fruit eating competition in an exhibition and note down the differences in taste of different fruits.
3. Bring some fresh and dried fruits to the school and evaluate as per the taste evaluation sheet given above.

Study Material

Exercise
Calculating the cost of production of important local fruits crops

Objectives

- To calculate the cost of production in fruit crop

Delivery schedule: 02 period

Student expectations / learning objectives

- To know the important operation in establishing the fruit orchards
- To know the cost of operation in fruit crops
- To learn how to calculate the cost of cultivation of fruit crops.

Handouts / material / equipment's & tools required: Paper sheet and pen to note down the different operation involved in cultivation of fruit crops. To note down the various cost involved in each operation being carried out.

Pre-learning required: Pre-requisite knowledge of some basic operation that are followed involved in cultivation of fruits crops

Introduction

The cost of cultivation of fruits is an important aspect in which one should know, how much a fruit grower is spending on production and after production, whether the grower is really able to get profit. It further gives an idea to maximize the output where, the unwanted expenditure is cut or minimized in order to get maximum return from unit area. It would be better to know the different operations that are being carried out in cultivation of fruit crops for calculating the cost of production.

To calculate the cost of productions of fruit crops, here is a list of items that are involved in cultivation are given below.

1. Labour cost: It can be computed based on the actual wages paid by the farmers in particular locality for men and women. In addition to labour hired, there are some work that are carried by the family members. In this case the wages will be calculated also as per the rate paid to the labourers.

2. Ploughing charges: For initial preparation of the field, the land should be ploughed thoroughly for this purpose one may use a tractor or power tiller or by bullocks drawn plough in cases where land holdings are small.

3. Material costs: The planting material used (seeds / seedlings / grafts) was valued at the current market
rate. Remaining material costs includes the expenditure on farmyard manures, fertilizers and plant protection chemicals.

4. **Other expenses:** includes packing materials (gunny bags / jutes / ropes) used while purchasing seedlings.

5. **Cost of cultivation:** It includes all the costs incurred annually for the maintenance and production of the fruit crops. The maintenance cost can be divided into variable cost and fixed cost. The variable cost includes the cost of farmyard manure, fertilizer, plant protection chemicals, irrigation charges, charges for electricity and labour cost for various operations. Fixed cost, is the cost which incurred one time like purchase of land or planting material, bore well charges etc.

6. **Gross income:** It is the value of total quantity of fruits produced per unit area at the current market prices, where the products are sold.

Before we go into different methods of analyzing the cost of fruit production, we should get familiar with the term discounting. This term is used in order to calculate the discounted cost in case the projects or farming benefit will be realized after a few years, until then the money incurred will bear some losses, in such cases it will bear the interest for the amount that was invested, so in order to calculate the actual benefit this loss also should be taken into account so that the actual profit can be calculated. Thus, we need to place current & future costs & benefits on an equal basis for comparison, This is done by “discounting,” that is by reducing future rupee to present value by applying a discount (or a negative interest) rate. The difference between the total discounted benefits and total discounted costs. Now the cost of cultivation can be calculated using following three methods.

1. Net Present Value (NPV)
2. Internal Rate of Return (IRR)
3. Benefit/Cost Ratio (BCR)

**What is Benefit/Cost Ratio (BCR)?**

BCR is the ratio between the Present value benefits (PVB) and Present value costs (PVC) and expressed as B/C = (PVb / PVC). B/C ratio which is greater than 1 indicates acceptability and for multiple (competing) projects, the project(s) with the highest B/C ratios (greater than 1) should receive highest priority.

**Example: Cost of cultivation of mango crop**

<table>
<thead>
<tr>
<th>Variable cost</th>
<th>Details charges</th>
<th>Rates 1st Year (Rs)</th>
<th>Rates second year onwards (Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Material cost</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I) Farm yard manure</td>
<td>15t / ha @ 1000/t</td>
<td>15,000</td>
<td>15,000</td>
</tr>
<tr>
<td>ii) Seeds / Planting materials</td>
<td>6x6m, 10000m² / 36m, 275 plants / ha @ 50rs / plant</td>
<td>13,750</td>
<td></td>
</tr>
<tr>
<td>iii) Plant protection chemicals</td>
<td>Fungicide, insecticides</td>
<td>6,000</td>
<td>6,000</td>
</tr>
<tr>
<td>iv) Chemical fertilizers</td>
<td>Recommended dose of NPK 0.5:0.5:0.75 kg/tree (after five years), Urea, DAP, MOP</td>
<td>16,000</td>
<td>16,000</td>
</tr>
</tbody>
</table>
### Economics of cultivation of mango

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Year</th>
<th>Yield (kg)</th>
<th>Inter crop Income (Rs)</th>
<th>Gross Returns (Rs)</th>
<th>Cost of Cultivations #</th>
<th>Net return (Rs).***</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>First year</td>
<td>-</td>
<td>75,000</td>
<td>75,000</td>
<td>3,25,250</td>
<td>-2,50,250</td>
</tr>
<tr>
<td>2.</td>
<td>Second year</td>
<td>-</td>
<td>75,000</td>
<td>75,000</td>
<td>1,54,000</td>
<td>-79,000</td>
</tr>
<tr>
<td></td>
<td>Third Year</td>
<td>1,500</td>
<td>75,000</td>
<td>1,20,000</td>
<td>1,54,000</td>
<td>-34,000</td>
</tr>
</tbody>
</table>
The gross return and cost of cultivation may vary with area of production, existing labour cost, market cost of the produce and the materials costs. The above calculations are sample of cost of cultivation. Therefore, in fruit crops the profit will be after sixth year onward depending upon the crop. For mango it will take minimum six year, in case of guava it starts bearing from third years, so the maximum profit will come from fourth year onwards.

**Students Activities**

- Visit to nearby orchards and try to note down different operations being carried out in fruit crops.
- You can also note down the charges for different activity and materials
- Try to work out the cost of cultivations of other fruit crops of the locality

**Study Material**

Exercise
Visiting a local market to know about marketing of different fruits and their identification

Objectives

- To visit a local market to identify different fruits and studying the marketing of different fruits.

Delivery Schedule: 02 periods

Students Expectations/learning objectives

- Identification of different fruits, which are being sold in the market
- Studying the marketing channels of fruit crops
- To know about traders, middle men, commission agents involved in marketing channel of fruit crops
- Finding out the scope of different fruits in the market

Handout and material required: Paper sheet, pen to note down the instructions, pictures of different fruits, agents and their mobile numbers.

Pre-learning required: Preliminary knowledge about different fruits and their perishable nature. Basic knowledge about marketing of fruit crops.

Introduction

Students may find different types of fruits sold at whole sale rates and retail rates during their visit to fruit market. Major fruits are mango, banana, grape, orange, mandarin, papaya, litchi, guava, figs, avocado, apple, plums, pear, peach, apricot, pomegranate, phalsa, jamun etc. Some times, students do not know the fruits. Hence, students can take help of the vendor or shopkeeper. When you go for a practical in the fruit market, please carry a book having coloured photographs of important fruit for easy identification. The demand for fruits is greatly increased in recent times with increase in the purchasing power and health awareness. Fruit growers usually find it easy to produce fruits but marketing of fruits is a big challenge. The major problem is not the perishable nature of fruits but marketing channels and lack of regulated fruit markets. As a result, fruits are sold through

For teachers...

- Arrange students visit to a fruit market.
- Ask the students to observe how farmers bring their fruits to mandi and how the sale agent starts bidding for fruit produce.
- Students should prepare list of whole sale rates of different fruits and compare them with the rates at retail counters.
- Ask students to note down activities they have observed during their visit to fruit market.
middlemen or commission agents, who earn maximum and farmers are getting less price of their fruit produce. It is therefore important for the students to know about marketing channels by interacting with the vendors, shopkeepers and fruit growers. In India there are few organizations (HOPCOMS, Mahagrape, Mahamango etc.) which help the fruit growers in getting reasonable prices of the fruit produce.

**Observations on market infrastructure**

In the market, students will find infrastructure facilities, which are required to avoid distress whole sale of fruits. The infrastructure facilities required for this purpose includes:

- Storage (go-down) facilities
- Cold storage facilities
- Availability of ripening chambers
- Better loading and weighing facilities
- Proper stalls
- Better road links

**Identification of different fruits with the help of photographs**

<table>
<thead>
<tr>
<th>Fruit</th>
<th>Photograph</th>
<th>Fruit</th>
<th>Photograph</th>
<th>Fruit</th>
<th>Photograph</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td><img src="image" alt="Apple" /></td>
<td>Papaya</td>
<td><img src="image" alt="Papaya" /></td>
<td>Mango</td>
<td><img src="image" alt="Mango" /></td>
</tr>
<tr>
<td>Banana</td>
<td><img src="image" alt="Banana" /></td>
<td>Peach</td>
<td><img src="image" alt="Peach" /></td>
<td>Grapes</td>
<td><img src="image" alt="Grapes" /></td>
</tr>
</tbody>
</table>
### Students Activities

- List out all the fruits available in the market you have visited and classify them in tropical, sub-tropical and temperate groups

- Make a list of infrastructure facilities available in the market you have visited

- Observe the difference between wholesale and retail prices of different fruits

- Note the different packaging material used for bulk handling and retail handling of different fruits

- List out all the activities which are necessary for getting higher rates for the produce

- Chalk out the possibility of marketing of the fruits which you grow in your orchard
Study Material


Exercise

Studying the use of gibberellic acid and other plant growth regulators in fruit crops.

Objectives

- To know about different kinds of growth regulators used in fruit crops
- To study the use of gibberellic acid and other growth promoting substances

Delivery schedule: 01 period

Student expectations/learning objectives

- To know about different growth regulators used in fruit crops
- To know about Gibberellic acid and its uses in fruit crops
- To learn different methods of application of gibberellic acid

Handouts / material / equipment’s & tools required: Paper sheet and pen to note down the use of different plant growth regulators and to note the methods of applications in fruit crops. Volumetric flask of different size beaker, precision balance, spatula, stirring glass rod etc.

Pre-learning required: Pre-requisite knowledge of plant growth regulators and their use in fruit crops.

Introduction

Chemical substances other than vitamins and nutrients having potential to regulate the plant growth when used in small quantities are known as plant growth regulators. The term plant growth regulator is broad in sense and used for endogenous as well as synthetic growth regulators. However, the term plant hormone is used for growth regulating substances produced endogenously. Different types of growth regulators like auxin, gibberellin, cytokin in, ethylene, retardants and inhibitors are useful in fruit production.

The stock solutions of auxins, gibberellins, cytokinins etc. should be prepared and can be stored in a refrigerator at near freezing temperature. Stock solution of auxin and other organic materials deteriorate with time. Some organic compounds are relatively insoluble in water. A small quantity of organic solvent (not more than 0.5 per cent of the final volume) is effective in dissolving most of the organic substances. Cytokinins are weak bases and can be dissolved in a dilute acid, whereas, auxins are weak acids and can be dissolved in a dilute base or in alcohol. Use of small quantity (0.3 to 0.5ml) of 1N HCl for cytokinin and NaOH/ KOH for auxin for each 10 mg of the compound is satisfactory.
<table>
<thead>
<tr>
<th>S. No.</th>
<th>Plant growth regulator</th>
<th>Examples</th>
</tr>
</thead>
</table>
| 1      | Auxins                 | - Indole Acetic Acid (IAA)  
- Indole Butyric Acid (IBA)  
- Naphthalene Acetic Acid (NAA)  
- 2, 4 – Dichlorophenoxy Acetic Acid (2, 4-D)  
- 4-Chloropenoxy Acetic Acid (4-CPA) |
| 2      | Gibberellic acid (GA)  | - Gibberellic acid 3 (Ga₃)  
- Gibberellic acid 4 (Ga₄)  
- Gibberellic acid 7 (Ga₇) |
| 3      | Cytokinin              | - Kinetin  
- Zeatin  
- Adenin  
- 6-benzyle amino purine (6-BAP)  
- Benzyle adenine (BA)  
- N-(2-chloro-4-pyriyl)-N-phenyl urea (4-CPPU) |
| 4      | Ethylene               | - 2-chloro ethyl phosphonic acid (Ethrel, Ethephon)  
- Chloroethyl phosphoric acid (CEPA) |
| 5      | Growth retardants      | - 2,4 Dichlorobenzyl (2,4 DNC)  
- Cycocel (CCC)  
- Alar  
- Paclobutrazol (PBZ) |
| 6      | Growth inhibitors      | - Abscissic acid (ABA)  
- Maleic hydrazide (MH)  
- Tri- iodobenzoic acid (TIBA) |

**Gibberellic acid**

Gibberellic acid (gibberellins) is a group of naturally occurring growth regulators stimulate the growth of many plants, promote flowering in some cases and cause a variety of other interesting morphological and physiological responses. Gibberellin was first discovered by late Elichi Kurosawa in 1926 in Japan from a rice diseased plant caused by a fungus (*Gibberella fujikuroi*). It produced taller plant than healthy ones. The first pure Gibberellin was called gibberellic acid (GA) named by Imperial Chemical Industries group. It is gibberellic acid (GA₃) produced and used in nearly all the horticultural crops.

**Methods of application of gibberellins**

**Liquid sprays:** This is the most convenient method, which is generally practiced. Gibberellic acid is
soluble in water only to the extent of 6000 parts per million (ppm). Therefore, a stock solution is prepared by dissolving one gram in 95 per cent ethyl alcohol with 0.1 per cent tween 20 (wetting agent) and diluting with water to make one litre of solutions. Desired further dilutions can be prepared from this stock solution as and when required.

**Liquid dip:** This is mostly used in case when the whole bunch has to be dipped. For example, in grapes the berry bunches are dipped in a beaker containing desired concentration of GA₃ solutions for seedlessness and elongation of berry.

**Lanolin paste:** This is an easy way to obtain a systematic application. One percent paste is prepared by placing 12.5 mg of the gibberellic acid into a small vial, then dissolving the acid with drops of a spreader and finally mixing it with one gram of melted lanolin.

**Aerosols:** Aerosols produce a dry spray over the entire plant leaving no powdery residue. The advantage of this method is that gibberellin is stable in the solvent used in aerosols, while it loses its activity when stored in contact with water. This method is also economical in case of a limited number of plants to be treated.

**Preparation of gibberellins solution**

**Steps 1. Stock solution preparation**

- Weigh 1.0 g of Ga₃ accurately on precision balance.
- Dissolve GA₃ in small quantity of 1N KOH / NaOH (generally 3 to 5 ml of solvent is sufficient for each 1000 mg quantity).
- Make volume to 1000 ml in a volumetric flask by adding double distilled water.
- Shake the volumetric flask gently for uniform dissolution.
- This will give 1000 ppm solution of GA₃.

**Step 2. Dilution of stock solution**

- As per requirement dilution may be done. For example, if students want to prepare 1000 ml solution of 50 ppm GA₃. Then calculation should be done by using the following formula, 

  $$ N1 \times V1 = N2 \times V2 $$

  Where,

  Calculation for preparation of 1.0 L (1000 ml) solution of 50 ppm GA₃,

  $$ N1 = \text{Concentration of stock solution} $$
  $$ V1 = \text{Volume of stock solution required} $$
  $$ N2 = \text{Concentration of solution has to be prepared} $$
  $$ V2 = \text{Volume of solution has to be prepared} $$

  $$ 1000 \text{ ppm} \ (N1) \times V1 = 50 \text{ ppm} \ (N2) \times 1000 \text{ ml} \ (V2) $$

  $$ V1 = (50 \times 1000) / 1000 $$
\[ V_1 = 50 \text{ ml} \]

**Result:** For preparing 1000 ml solution of 50 ppm GA, Students should take 50 ml of 1000 ppm Ga, stock solution and dilute it to make 1000 ml by adding double distilled water.

**Students Activities**

1. Visit to nearby orchards and note down about different plant growth regulators used in the orchards.

2. Prepare stocks solution (1000 ppm) of gibberellin and cytokinin. Dilute stock solution to a desired concentration and practice spray on fruit plants.

3. Practice different methods of GA, application on fruit plants.

4. Visit agro-chemical shops in the locality and note down different types of plant growth regulators sold there.

**Study Material**


REJUVENATION OF OLD AND SENILE FRUIT ORCHARDS

Exercise
Orchard rejuvenation: making rings, application of fertilizers and root pruning

Objectives

- To know about rejuvenation procedures in old and senile fruit orchards.
- To know about top working of old and unproductive fruit trees with superior scion varieties.

Delivery schedule: 02 periods

Student expectations/learning objectives:

- To know about rejuvenation practices in different fruit crops.
- To know about cultural practices in rejuvenated fruit orchards.
- To know about top working of old and unproductive fruit trees.

Handouts/material/equipment’s & tools required: Paper sheet and pen to note down the different important points pertaining to rejuvenation in fruit orchards.

Pre-learning required: Pre-requisite knowledge of fruit species and their cultivation practices.

Introduction

The term 'Rejuvenation' means renewal or making new or young again. As applied to the fruit trees it would mean restoring the productive capacity of the fruit trees which have attained a stage where they are no more profitable. Students might have observed that in poorly managed old and senile fruit orchards having inter-mingling and over-crowding of shoots with poor photosynthetic efficiency, severe infestation of insect pests and diseases. Senile orchards with poor efficiency are now a common phenomenon in temperate, sub-tropical and tropical fruits. Since most of the fruit crops have long juvenile phase, instead of planting new plantations, it is advisable to rejuvenate them to have new vigour which will ultimately leads to better and quality production.

Month wise rejuvenation activities

December - January

- Mark trees and undesired branches for severe pruning.
- Prune marked branches of fruit trees preferably in December.
- Pruning should be done in alternate rows.
- Avoid cracking and splitting by cutting the branches first from lower side and then from upper side.
• Apply copper oxychloride paste or biodynamic tree paste on all cut surfaces.

• Deep ploughing of the orchards in January.

• Prepare irrigation channels and tree basin in the orchard.

**February - March**

• Apply recommended full dose of phosphorus and half dose of nitrogen in the fruit tree basins in the second fortnight of February.

• If infestation of stem borer and other insect pest on pruned fruit trees is seen. Treat trees with monocrotophos or chlorpyriphos (0.05 per cent) or dichlorvos or kerosene oil upon identification of infestation.

• In March irrigate pruned trees as per their requirement.

**April - May**

• Irrigation as per requirement of fruit trees.

• Apply mulch material in the fruit tree basin.

• Perform hoeing and weeding in tree basins.

• Protect new emerging shoots from the pruned trees.

• Observation for incidence of stem-borer and its management as given above.

**June - July**

• Thin out undesired shoots and retain 6-10 healthy shoots with outwardly growth per pruned branch during June.

• Spray of copper oxychloride (3 g/liter) on trees.

• Irrigate fruit trees at an interval of 10-15 days.

• Application of remaining half dose of nitrogen during June.

• Apply farm yard manure (75-100 kg per tree) in tree basins during July month.

• Careful watch the infestation of stem borer and manage as given above.

• Spray of copper oxychloride (3 g/litre water) twice at an interval of 15 days, if symptoms of diseases like anthracnose and leaf spot appear on new growth.

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**For teachers..**

• Practically show the old, crowded, unproductive fruit orchards to the students.

• Demonstrate before students marking and pruning of undesirable branches.

• Try to make the students to understand seedling origin fruit trees and superior scion
- Spray carbarly (2 g per litre water) at an interval of 10-15 days if incidence of leaf cutting weevil is observed.

**August - September**

- Thin out other undesired shoots.
- Observation of incidence of stem-borer insect pest and anthracnose and other leaf spot diseases and their management.

**October-November**

- Cultural operations such as ploughing, hoeing, weeding should be done.
- Remove dried and diseased twigs on the fruit trees.
- Control insect pests and disease on the fruit trees.
- Spray urea (2 per cent) in October for healthy vegetative growth.
- Marking of remaining trees for pruning in the December month.

**Rejuvenation in mango**

Emergence of new shoot from the pruned branches

Rejuvenated mango trees

Fruiting in rejuvenated mango trees
In mango, 40 to 60 years old plantation can be further given a productive life of 20 to 25 years by adopting rejuvenation practices. Rejuvenation consists of heading back and removal of selected branches three to four meters above ground during winter month. Proper orchard management which includes immediate pasting by copper oxychloride or bordeaux paste or cow dung paste, thinning of unwanted shoots, nutrient and water management need to be scientifically practiced. In case original varieties are of poor quality, or there is no provision of pollinizers, top working of elite clone(s) need to be adopted. These rejuvenated trees start bearing from third year onwards. Branches emerging from the main trunk have been considered to be the first order and subsequent branches have been assigned higher orders respectively. There is good income realization from the sale of pruned wood and cultivation of appropriate intercrops. Thus, it is clear that the open space could be profitably utilized for inter-cultivation of vegetables, medicinal and aromatic crops, and even short duration horticultural crops like papaya and drumstick, etc. particularly in early years of rejuvenation. The rejuvenation technology in mango involves various steps depends on condition of orchard and age of the fruit plants.

**Canopy management**

- Older plantations of seedling origin can be adopted for top working by grafting with superior varieties.
- Over lapping of canopy may be observed between 10 and 12 years of age. Maintained the canopy by thinning and trimming.

**Irrigation, manuring and fertilization**

- For mango, Urea (2.5 kg), Single Super Phosphate (3 kg) and Potassium sulphate (1.5 kg) and 75 kg farm yard manure is suggested.
- Full dose of farm yard manure (120 kg/tree) should be applied in the first week of July.
- In the last week of February, apply half dose of urea with full dose of Single Super Phosphate and Potassium Sulphate.
- The remaining half dose of urea is applied during June.
- Adequate watering is essential for the development of shoots on rejuvenated trees. Pruned trees need to be irrigated at 10-15 days interval form March to June.

**Mulching**

- Mulching under pruned trees by black alkathane sheet or organic material, such as, dried grass, banana leaves etc..
- Optimum soil moisture should be ensured after new shoots emergence on pruned trees.

**Thinning of shoots**

- Selective and regular thinning of shoots is essential for the development of open canopy of healthy shoots.
- Outwardly growing 8-10 healthy shoots are retained per branch and the rest are removed.
- Spray copper oxychloride (3 g/ litre water) after thinning operations.

**Insect pest and disease management**

- Infestation of stem-borer can be easily identified by wooden frass fallen on ground from the affected branches. Holes and oozing of gum in affected branches are the other indicators of borer infestation.
- Larvae can be killed or pulled out from the hole by using thin wire.
- Larvae hidden inside the branch and trunk can be effectively controlled by placing cotton wick soaked in insecticide inside the hole and sealing it with mud.
- Leaf cutting weevil damages new growth. It can be managed by spraying carbaryl (0.2 per cent) at 10-15 days interval.
- The anthracnose disease on leaves can be controlled by spraying Copper oxychloride (0.3 per cent) at 15 days interval.

**Students Activities**

1. The students should perform marking and pruning operations on old and unproductive fruit trees available in the locality.
2. Students should be asked to manage the pruned trees and to make a schedule of operation required in different months.
3. Students should be asked to top work seedling type unproductive fruit trees with the superior varieties.
4. Students should be asked to prepare solution/paste of different plant protection chemical required during rejuvenation of fruit trees.

**Study Material**
